

Cornell 1937

Protecting Orchard Crops From Diseases and Insects In the Hudson Valley

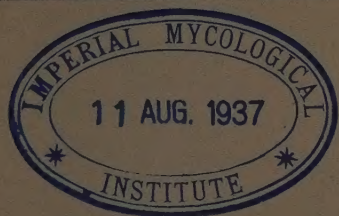
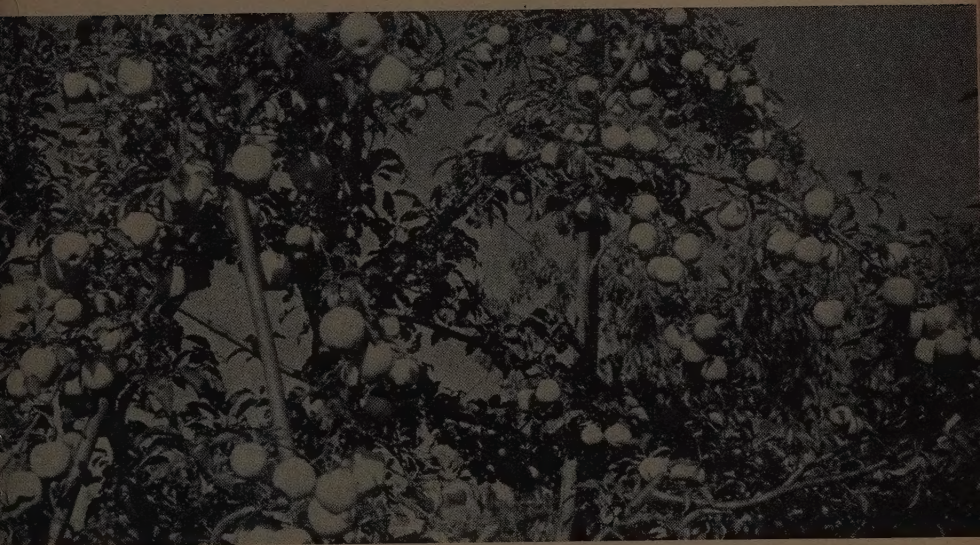
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C. R. CROSBY, W. D. MILLS, AND J. A. EVANS



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PROTECTING ORCHARD CROPS FROM DISEASES AND INSECTS IN THE HUDSON VALLEY

C. R. CROSBY, W. D. MILLS, AND J. A. EVANS

In this bulletin an attempt is made to bring together in available form all the more important facts concerning the practical control of orchard diseases and insects by spraying and dusting under New York conditions. Much of the material has been published in bulletins or elsewhere but is available only to those having access to an extensive agricultural library. Considerable additional information has been obtained from unpublished data of the research workers of the state experiment stations. Many valuable suggestions have been received also from the farm-bureau workers engaged in conducting the spray-information service. Furthermore, the practices followed by successful fruit-growers have been given careful consideration, for the final test of any spraying program must be the results obtained under commercial conditions. It is hoped that this summary will be of use to the growers of the Hudson Valley in their efforts to produce clean crops of fruit economically.

Dr. P. J. Chapman and Dr. J. M. Hamilton, of the New York Agricultural Experiment Station, at Geneva, have been conducting extensive experiments in control of orchard insects and diseases in the Hudson Valley for several years. They have cooperated in the preparation of this bulletin by making the results of their investigations freely available, by giving valuable advice in regard to schedules and recommendations, and by carefully reading the manuscript. Other members of the Experiment Station staff have aided with pertinent suggestions and advice.

APPLES

In working out an effective program for apples, the most important problems to be solved are the control of apple scab, of codling moth, of apple maggot, of plum curculio, and of rosy aphid. While these troubles vary in relative importance with the year, the variety, and the locality, they are always of sufficient importance in the Hudson Valley to be given careful consideration in planning a spray program. Occasionally, cedar rust, the leaf-roller, the scurfy scale, and the green aphid become of major importance either locally or generally throughout the region. Other diseases and insects are restricted in importance to more or less definite areas. Owing to these variations in importance of the different insects and diseases with locality and year, the following schedule must be considered as a general outline of the spray program, to be modified to meet

the actual conditions in the orchards to be treated. In counties where the farm bureau conducts a spray information service, valuable assistance in adapting the general recommendations to individual needs may be obtained on request.

SPRAY OUTLINE FOR APPLES

Dormant spray

For the control of rosy aphid, tar-distillate emulsion containing 2.4 per cent of creosote oil in the diluted mixture may be applied while the buds are dormant. If the amount of creosote oil is increased to 3 per cent, it will also control light infestations of oyster-shell scale and bud moth. For heavy infestations of these insects, a 4.5-per-cent mixture should be used. Where scurfy scale is a problem, a 4-per-cent mixture should be used. The different brands of tar-distillate emulsions vary slightly in composition. Proper dilutions are given in table 2 on page 96. Tar-distillate emulsions should not be applied after the buds have begun to show gray at the tip or on trees that are winter-injured.

For San José scale and red-mite eggs, a 3-per-cent lubricating-oil emulsion may be used. Under certain conditions the oil emulsion may be combined with a tar-distillate emulsion.

For the fruit-tree leaf-roller, lubricating-oil emulsion diluted to contain 6 per cent of oil in the spray may be applied. The treatment is best made after the buds have begun to swell but before they show green at the tip.

Green-tip spray

The green-tip spray is suggested in large orchards where it has been difficult to cover the entire orchard for aphid control in the limited time permitted at the regular delayed-dormant stage. While nicotine sulfate and lime sulfur 1-50 usually proves most satisfactory at the delayed-dormant stage than at other times, it has been found possible to obtain commercial control with nicotine and a 3 per cent lubricating-oil emulsion when the buds are showing green tips and the aphid eggs are not yet hatched. At this time the eggs are susceptible to the effect of nicotine sulfate in combination with lubricating-oil emulsion as given in the following formula:

*Bordeaux mixture (see page 95).....	2-4-100
Lubricating oil	3 gallons
Nicotine sulfate	1 pint
Water to make	100 gallons

*The bordeaux is used to emulsify the oil (see page 95) and will also aid in preventing early apple-scab infection. If scab is not a problem, $\frac{1}{2}$ pound of lignin-pitch may be used instead of the bordeaux mixture to emulsify the oil.

San José scale, bud moth, and European red mite are also held in check by this application.

Delayed-dormant spray (When the leaves of the blossom buds are out from $\frac{1}{4}$ to $\frac{1}{2}$ inch)

Lime-sulfur	2 gallons
Hydrated lime	3 pounds
Lead arsenate	3 pounds
Lignin-pitch	$\frac{1}{2}$ pound
Nicotine sulfate	1 pint
Water to make	100 gallons

Lime-sulfur is included for the control of apple scab.

Lead arsenate is used for the control of case-bearers, the tent caterpillar, and other chewing insects. It is of value also in the control of apple scab.

Nicotine sulfate is used primarily against the rosy and green aphids and the bud-moth larvae. If the trees have been sprayed with tar-distillate emulsion, or with nicotine sulfate in the green-tip application, the nicotine may be omitted in the delayed-dormant application. For the nicotine spray to be most effective against the rosy aphid, it is necessary to delay spraying until nearly all the eggs have hatched. Under normal weather conditions this has taken place by the time the opening leaves have reached the stage indicated, and that is usually early enough for scab control. In exceptional seasons, however, apple-scab infection may occur before the aphid eggs have hatched. Under such circumstances bordeaux mixture in the green-tip application, or an additional early application of 2 gallons of lime-sulfur, may be required for scab control before the delayed-dormant spray.

Some growers prefer to apply the oil spray at the delayed-dormant stage instead of the dormant or green-tip stage for the control of scale and red mite. The oil is emulsified with weak bordeaux mixture. If the bordeaux is used at a strength containing 2 pounds of copper sulfate and 4 pounds of hydrated lime in 100 gallons of water, it will prevent early scab infections. The spray should be completed before the leaves roll back and expose the blossom buds, to avoid the danger of russetting the fruit.

Pre-blossom sprays

Lime-sulfur	2 gallons
Hydrated lime	3 pounds
Lead arsenate	3 pounds
Lignin-pitch	$\frac{1}{2}$ pound
Water to make.....	100 gallons

The pre-blossom spray or sprays, applied between the delayed-dormant spray and the bloom, are timed primarily for scab control. The points to be considered in timing the applications are: the occurrence of rain periods; the amount of new growth; and the stage of development of the scab fungus. In some seasons two pre-blossom applications may be required for effective scab control, especially on extremely susceptible varieties such as McIntosh.

If dust is used, a 90-10 sulfur-lead-arsenate mixture is indicated. If conditions are favorable for severe scab infection, the grower should spray as much as possible, using dust to complete the operation on time.

Calyx spray (When the last of the petals are falling)

Lime-sulfur	2 gallons
Hydrated lime	3 pounds
Lead arsenate	3 pounds
Lignin-pitch	$\frac{1}{2}$ pound
Nicotine sulfate.....	1 pint
Water to make.....	100 gallons

If red bugs are not present, nicotine sulfate should be omitted.

If wet weather prevails during bloom and if scab control is doubtful, or if scab spots are present on the leaves, lime-sulfur is preferred. With dry weather during bloom and no scab present, wettable sulfurs may be used to reduce the danger of spray injury.

The calyx spray is applied chiefly to control apple scab and to poison the codling-moth larvae which later enter the blossom end of the fruit.

If dust is used, a 90-10 sulfur-lead-arsenate mixture is indicated. If conditions are favorable for a heavy infection of scab, the grower should spray as much as possible, using dust as a supplementary measure. If redbugs are to be controlled, a separate application of a 2-per-cent-nicotine lime dust is indicated.

Curculio spray (Seven to ten days after the calyx spray)

Lime-sulfur	2 gallons
Hydrated lime	3 pounds
Lead arsenate	3 pounds
Lignin-pitch	$\frac{1}{2}$ pound
Water to make.....	100 gallons

This spray is timed primarily for the control of the plum curculio, but it is also very important for the control of apple scab. The same considerations exist as in the calyx application with respect to the substitution of wettable sulfurs for liquid lime-sulfur in this application.

Summer sprays

In planning a spraying schedule for the summer applications—that is, after the calyx or the curculio spray—it must be kept in mind that the regulations of the Federal Food and Drug Administration do not permit more than 0.01 grain of arsenic trioxide or more than 0.018 grain of lead per pound of fruit. A tolerance of 0.01 grain of fluorine per pound of fruit is allowed. These requirements may be met either by removing the residue by washing, or by modifying the schedule to keep the residue below tolerance. Washing is an additional expense; a modification of the schedule to keep the residue below tolerance is likely to result in serious loss from codling-moth and apple-maggot infestation. If the grower is in a position to have his crop washed, he can follow a schedule designed to give adequate protection against these pests. It is at present impossible to suggest a satisfactory schedule for those who cannot wash their fruit. The later sprays may be omitted or the strength of the insecticide reduced; but this is likely to result in heavy losses from codling moth and apple maggot, and will not insure freedom from excessive residue in all cases.

The purpose of the summer sprays is to control codling moth, apple maggot, and apple scab.

It is the usual practice to include a fungicide in all of the summer sprays for scab control. If a lime-sulfur schedule has been used through the primary infection and practically all early infections have been prevented, it is advisable to use one of the wettable sulfurs as a fungicide in the summer applications to reduce the danger of injury to foliage and fruit. In seasons when scab is not a problem, the fungicide may be omitted from some of the summer sprays during or preceding hot periods. However, a fungicide should be included in the last summer application unless a thorough examination of the trees, especially in the tops, show scab is not a problem.

The following schedule is intended for those who desire to obtain a maximum of protection without running into difficulties from excessive spray residues.

First codling-moth cover spray (About June 10 to 15)

Lime-sulfur	2 gallons
or	
Wettable sulfur (at manufacturer's directions)	
Hydrated lime	3 pounds
Lead arsenate	3 pounds
Lignin-pitch	½ pound
Water to make.....	100 gallons

If dust is used, a 90-10 sulfur-lead arsenate mixture is indicated.

First apple-maggot spray, or second codling-moth cover spray (About June 25 to July 1)

Formula for varieties ripening later than McIntosh

Wettable sulfur (at manufacturers' directions)

or

Lime-sulfur (if scab is a problem)..... 2 gallons

Hydrated lime 3 pounds

Lead arsenate 3 pounds

Water to make..... 100 gallons

For a spreader (see page 92) at this time, $\frac{1}{2}$ pound of skimmilk powder or 1 pound of soybean flour may be used. If dust is used for this application, a 90-10 sulfur-lead-arsenate mixture is suggested.

For McIntosh and other early varieties

Wettable sulfur at manufacturers' direction

or

Lime-sulfur (if scab is a problem)..... 2 gallons

Calcium arsenate (see page 91)..... 3 pounds

Hydrated lime 9 pounds

Water to make..... 100 gallons

For a spreader (see page 92) at this time, $\frac{1}{2}$ pound of skimmilk powder may be used.

If dust is used for this application a 90-10 sulfur-lead arsenate mixture is suggested.

Second apple-maggot spray, or third codling-moth cover spray (About July 15)

To prevent excessive spray residues, the use of calcium arsenate is suggested at this time on all varieties as follows:

Wettable sulfur (at manufacturers' directions)

Calcium arsenate 2 pounds

Hydrated lime 6 pounds

Water to make..... 100 gallons

For a spreader (see page 92) at this time, $\frac{1}{2}$ pound of skimmilk powder may be used.

If dust is used for this application, a 90-10 sulfur-lead-arsenate mixture is suggested.

The following formula is suggested for use in orchards where the fruit can be adequately cleaned if necessary:

Wettable sulfurs (at manufacturers' directions)

or	
Lime-sulfur	2 gallons
and	
Hydrated lime	3 pounds
Lead arsenate	3 pounds
Spreader	$\frac{1}{2}$ pound
Water to make.....	100 gallons

If dust is used, a 90-10 sulfur-lead-arsenate mixture is indicated. The same precautions concerning residue should be taken in dusting as in spraying. During prolonged rain periods, it is advisable to make dust applications at shorter intervals than are indicated for spray mixtures. When there is already some scab on the foliage, control is made more effective by relying on applications of liquid lime-sulfur spray, since thorough applications of the material will burn out the scab lesions and will prevent in large measure the formation and spread of summer spores. However, the danger from heavy applications of liquid lime-sulfur during the summer should not be overlooked.

PLANT LICE

Three species of plant lice, or aphids, may appear on the opening buds of the apple: the grain aphid, the green aphid, and the rosy aphid. These three species differ considerably in their life history, their habits, and the type of injury which they cause.

All three of these species of plant lice pass the winter in the egg stage on the bark of the apple. The eggs, about $\frac{1}{32}$ inch long, are black, shiny, and elliptical in shape. The grain aphids hatch just as the buds are showing green, and the green and rosy aphids appear a week to ten days later. In normal seasons, all three species have completed hatching by the time the leaves of the blossom clusters are out $\frac{1}{2}$ inch and are beginning to turn back at the tip.

All of the lice that hatch from the eggs are females, and, when mature, are known as *stem mothers*. Soon after hatching, the insect inserts its bristle-like mouth-parts into the leaf and begins to suck out the plant juices. As the young aphid increases in size it molts its skin three times, and after the third molt it is a mature female which in a short time begins to give birth to living young. Reproduction continues in this manner throughout the summer, and no eggs are laid until fall.

Grain aphis

(*Rhopalosiphum prunifoliae* Fitch)

The grain aphis, although often appearing in the greatest numbers on the opening buds, causes very little damage to the apple, since it leaves the trees early in the season. It hatches as soon as the buds show green, and is usually the most abundant species on the opening buds. The newly hatched aphids are dark yellowish green, and may be distinguished under a strong lens by the cornicles, which are so short as to appear like low tubercles (figure 1, C). The mature stem mother is yellowish green, with a dark green band extending the full length of the body and expanded laterally along the edges of each segment. The majority of the second generation acquire wings and migrate to their summer food plants without causing any serious injury to the apple. This species lives on grains and grasses until October or November, when males and females are produced. These return to the apple, where the winter eggs are deposited.

Rosy aphis

(*Anuraphis roseus* Baker)

The rosy aphis is usually by far the most destructive species of aphid that attacks the apple. It varies greatly in abundance from year to year. Major outbreaks have occurred at intervals of several years in the Hudson Valley, and in some seasons the rosy aphid is so scarce as to cause practically no damage. In most years, however, this aphid is present in small numbers in most orchards. It is very destructive to Baldwin, Rhode Island Greening, Cortland, Rome Beauty, Jonathan, Maiden Blush, Twenty Ounce, and Northern Spy. McIntosh, Duchess, and Wealthy usually escape serious injury. The eggs are deposited abundantly on these varieties and great numbers of the newly hatched aphids may be found on the opening buds. They do not thrive here and usually disappear without causing any damage to the fruit.

The newly hatched nymphs are very dark green, and may be distinguished from the other species by the longer cornicles, which are flanged at the tip (figure 1, B). The mature aphids vary considerably in color, but are usually of a dark bluish slate color and are covered with a waxy bloom or powder. In later generations the insects usually take on a pinkish or a rosy tinge. The stem mothers

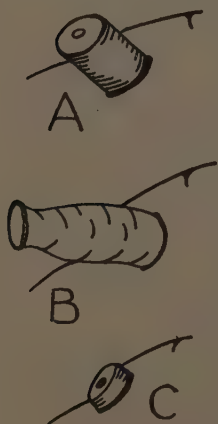


FIGURE 1. CORNICLES OF THE NEWLY HATCHED STEM MOTHERS

A, Green aphid; B, rosy aphid; C, grain aphid.
The cornicles are two small tubes projecting from the back of the insect near the hind extremity



FIGURE 2. APPLES INJURED BY THE ROSY APHIS

mature and begin to produce young at about the time the blossoms show pink. The second generation begins to reproduce just as the fruit is setting. The third generation becomes mature about the middle of June, just as the young apples begin their period of rapid growth. At this time representatives of all three generations are producing young simultaneously. The rosy aphid has the habit of clustering on the leaves of the fruit spurs and on the stems of the young fruits, as well as on the fruits themselves. This habit, together with the enormous reproduction of the species, explains how the insect is capable of causing such serious injury. The rapidly forming apples are in a tender condition at the time when the aphids are most abundant. Apples injured by the rosy aphid are dwarfed, deformed, poorly colored, and characteristically puckered at the blossom end (figure 2). When the young apples have been injured by the aphid,

the natural thinning known as the "June drop" does not occur, with the result that the tree is covered with numerous clusters of small, misshapen apples. The feeding of the rosy aphid on the leaves causes them to curl tightly and roll up diagonally like a cigar wrapper. One or two aphids to a leaf are enough to produce curling. The curled leaves protect the lice not only from heavy rains but also from the spray. Fortunately, the rosy aphid does not stay on the apple throughout the season. The majority of the third and fourth generations acquire wings and migrate to narrow-leaved plantain, where they remain until late autumn.

Control

Two methods of controlling the rosy aphid have been found of value under commercial conditions — spraying with tar-distillate emulsion and spraying with nicotine sulfate.

Control with tar-distillate emulsion

The eggs of aphids may be killed by spraying in the spring, before the buds show gray at the tip, with tar-distillate emulsion containing 2.4 per cent of tar oil in the diluted mixture. If the amount of tar oil is increased to 4 per cent, the emulsion will also control scurfy scale, oyster-shell scale, and bud moth.

Control with nicotine sulfate

Nicotine sulfate can be used against the rosy aphid in both the green-tip and delayed-dormant applications. The nicotine with lime-sulfur 1-50 is more effective in the delayed-dormant than in the green-tip spray, but, since it is often difficult to treat the entire orchard at the proper time, it is possible to obtain commercial control by using the nicotine with oil at the green-tip stage. Either of these sprays will serve to hold bud moth in check.

Nicotine at green-tip stage

The most promising combination at the green-tip stage is 1 pint of nicotine sulfate in combination with a 3-per-cent lubricating-oil emulsion "emulsified with a 2-4-100 bordeaux mixture. While, at the green-tip stage, the aphid eggs have not yet hatched, they have reached a condition in which they are susceptible to the effects of the nicotine and oil combination. The bordeaux mixture is of value as a fungicide in years when there is danger of a very early apple-scab infection.

Nicotine at delayed-dormant stage

At the delayed-dormant stage (leaves projecting from $\frac{1}{4}$ to $\frac{1}{2}$ inch from the blossom buds) the aphid have practically all hatched and have congregated on the opening buds where they can be hit with the

spray. At this stage the nicotine is usually combined with lime-sulfur and lead arsenate, as indicated in the formula on page 7.

If the application of this spray is delayed until the leaves have begun to curl, so as to afford hiding places for the lice, poor control may result.

Applying the spray

It should be remembered that the rosy aphid is a difficult pest to control. Low temperatures and strong winds greatly reduce the effectiveness of the nicotine and make proper coverage difficult; therefore, whenever possible, this application should be made in warm, quiet weather. The young aphids are very sensitive to cold winds and are constantly moving about on the buds to avoid the wind and to keep in the sunshine as much as possible. For this reason, all sides of the buds must be completely covered at the same operation. If the lee side is left to be sprayed when the wind changes, many of the aphids sheltered there will escape. Complete coverage of the buds can be accomplished only by wetting them from several different angles. This cannot be done by spraying from the tank alone. On very low trees and with favorable winds, complete coverage of the buds may be insured by spraying from the ground only, using a long hose. The operator should walk around and under the tree, directing the spray material against the buds from as many angles as possible. Each branch of the tree should be wet by directing the spray diagonally into the wind as the operator approaches it and after he has passed it. On high trees, complete coverage is best accomplished with the ground lead of hose operated as already suggested, and an additional hose operated from the tank or the tower. The operator on the tank or the tower also should spray each part of the tree as he approaches it and after he has passed it. Such coverage will require very liberal quantities of spray materials. This system of spraying does not require that the entire tree be covered at one operation, although this may be done if the trees are low and the wind is not too strong. On high trees, where it is not possible to completely cover the tree at one operation, as much of the tree as possible should be sprayed, as previously outlined, and the remainder finished as soon as the wind permits. In some seasons, when the wind does not shift to the desired direction, it may be necessary to "fight" the wind in order to complete the operation on time.

Green aphid

(*Aphis pomi* DeGeer)

The green aphid has a tendency to attack the tender growing shoots, and its most serious injury is the dwarfing of new growth of nursery stock and young plantings. In occasional years, however, it causes serious injury to fruit and foliage in bearing orchards.

The eggs of the green aphid hatch at about the same time as or slightly earlier than do those of the rosy aphid. The newly hatched nymphs of this species are dark apple-green in color, and may be distinguished under a lens by their short, cylindrical cornicles (figure 1, A). The mature stem mothers are bright yellowish green, with the cornicles and the tips of the antennae black. The green aphid lives on the apple throughout the season, but many individuals of the second and third generations acquire wings and migrate not only to other apple trees but also to pear, quince, and spiraea.

In normal seasons, during the early summer the green aphids are reduced to small numbers by the attacks of various insect enemies. Occasionally, during midsummer, weather conditions are favorable for the development of aphids and unfavorable for their enemies. Under such conditions the aphids not only increase to enormous numbers in previously infested orchards, but also develop large numbers of winged individuals which migrate in swarms to other trees that were free from the pest earlier in the season. When this occurs, the insects cause serious dying-back of shoots in nursery stock and young trees. In bearing orchards they cause not only considerable injury to the foliage and the terminal shoots, but also serious damage to the fruit by invading the fruit clusters. Extended feeding of the aphids on the young fruits causes the fruits to be dwarfed and misshapen; if the feeding is less prolonged, it produces a roughened, pitted surface, and sometimes a reddish stippling or spotting of the skin similar to that caused by San José scale. The aphids also cover the fruit and the foliage with sticky honeydew, on which a black, sooty fungus grows, this often staining the fruit so badly as to greatly reduce its market value.

Control

The green aphid in bearing orchards is to a large extent controlled by the treatment given for the rosy aphid. These sprays do not insure complete protection from green aphid throughout the season, because, beginning with the second generation, a large proportion of the green aphids are winged, and in years of summer outbreaks they migrate in considerable numbers and infest clean orchards. As a general rule, however, trees receiving a thorough delayed-dormant spray with nicotine or a dormant application of tar-distillate emulsion are less likely to be seriously infested by the green aphid.

When summer outbreaks occur, serious damage to the fruit crop may result unless special control measures are used. All suckers and water sprouts should be removed from the trees; the aphids breed on these in large numbers. When green aphids appear in considerable numbers on the terminals of bearing trees, they should be watched closely. As long

as they confine their feeding to the terminal shoots and the leaf clusters, the special spray may be withheld in the hope that natural agencies will keep the aphids within bounds. If, however, the aphids invade the fruit clusters, a spray should be applied at once, using nicotine sulfate, 1 pint combined with 3 to 5 pounds of potash fish oil soap or 1 pound of soap flakes in 100 gallons of the spray mixture.

APPLE SCAB

(Caused by the fungus *Venturia inaequalis* (Cooke) Winter)

The commonest and most destructive disease of apples in New York is apple scab. Every fruit-grower knows the tremendous damage to the apple crop caused by scab. It is less well known that, in some years, early scab infection on the fruit pedicels, when not controlled, almost entirely prevents the setting of fruit. Another loss not always recognized is the weakening of the trees following severe leaf infection, a condition which results in the reduction of later crops.

The scab fungus commonly affects the fruit and the leaves, but it may be found also on the leaf stalks, on the flowers, and, rarely in New York, on the twigs.

The first appearance of the scab on the leaves is a dull, smoky area, which is difficult to be seen without careful examination. A little later the spots become more olive-colored, velvety, and much more noticeable. If leaf infections occur before the leaves of the clusters have rolled back, considerable numbers of these spots will be found on the under surface of the leaves.

The first infections on the fruit may occur on the sepals when only green tips are showing on the fruit buds. These sepal infections resemble closely the leaf infections, and are often overlooked. When sepal infections are present, the scab fungus later spreads from them to the surface of the fruit, resulting in scab spots near the calyx end of the apple. The spots on the fruit itself, regardless of their source, first appear as small, circular, olive-colored areas; but later, as the fungus spreads and the fruit grows, the familiar scabby spots are produced (figure 3), sometimes being accompanied by a cracking of the fruit.

The appearance on the leaf stalks and on the flowers is similar to that on the leaves. The scab spots on the twigs vary with the variety of apple, but often become somewhat swollen, with a blistered or a scurfy appearance.

Apple scab is caused by a fungus which overwinters in the old fallen leaves as partly grown fruiting bodies. These fruiting bodies ripen in the early spring. The date of ripening varies slightly with the variety of apple, but is largely determined by weather conditions. In the Hudson



FIGURE 3. APPLE SCAB ON THE UPPER AND LOWER SURFACES OF LEAVES
AND ON THE FRUIT

Valley, in many years these fruiting bodies (perithecia) are ripe and ready to discharge their first spring spores (ascospores) by the time the delayed-dormant spray is applied; that is, when the leaves of the blossom buds are out from $\frac{1}{4}$ to $\frac{1}{2}$ inch. Rain for a few minutes is sufficient to wet the old leaves on the ground and to cause the shooting of the ascospores

to a distance of about $\frac{1}{4}$ inch from the leaves. Air currents then carry the light spores long distances, and many of them settle on the green parts of the apple trees. This shooting of spores usually continues, during wet weather, for four to six weeks. The supply of ascospores is usually exhausted from four to five weeks after the petals have fallen.

If the green tissue is wet when the spore lodges, and remains wet for a sufficiently long time, the spore will germinate and send its sprouts or its germ tube into the tissue. The time required for the spore to germinate and grow into the green tissue varies with the temperature. The shortest time required is at temperatures between 60° and 70° F., while much longer periods of wetting are required when the temperature is near the freezing point.

After the fungus has penetrated the leaf or other green tissue, it grows under the cuticle for seven to eighteen days, and then sends up stalks on which the summer spores, or conidia, are borne. These summer spores when dry are firmly attached to the stalks bearing them, but when wet they promptly become detached. They are not blown long distances as are the ascospores from the old fallen leaves. Water is required to loosen summer spores, which then are washed to new locations and are scattered only so far as the water is splashed or blown. When these summer spores are carried to other leaves or fruit, they germinate and send germ tubes into the tissues to form new spots. This continues during rain periods throughout the summer. When the scabby leaves drop to the ground in the fall, fruiting bodies start to develop in them. These fruiting bodies will go through the winter and will serve to start scab infections in the following spring.

Control

From a study of the life history of the scab fungus, it would seem that the disease might be controlled by destroying the dead leaves in which the fungus overwinters. Plowing-under the leaves reduces greatly the number of fruiting bodies and of ascospores discharged in the spring. Unfortunately this has not been found to be of much practical benefit, for, with the most careful work, there are still considerable numbers of leaves left uncovered around tree trunks, along fences, and in other protected places. One tree may have enough leaves under it for 2,000,000,000 spores, so that if 90 per cent were destroyed there still would be enough left to give abundant infections. If it were possible to destroy every leaf in the orchard, there still would be the wind-borne spores from other apples trees to contend with.

The practical method of control has proved to be the covering of the green tissue of fruit and leaves with a protective coating of a material

which will prevent the spores from germinating and entering the tissue. The materials found to be most effective for the purpose are sulfur and copper. Sulfur is most commonly used in the form of lime-sulfur spray, wettable sulfur sprays, and sulfur dusts. Copper is used in the form of bordeaux-mixture spray. Unfortunately, under New York conditions the danger of injury to the fruit and the leaves of the apple from copper compounds is so great that sulfur compounds have almost entirely supplanted them.

Since the scab fungus spreads only during wet weather, it is essential that the protective coating be applied before rain periods. A considerable degree of scab control may be obtained also, in many instances, by applying liquid lime-sulfur immediately after the rain infection period. Sulfur applied in the form of lime-sulfur or sulfur dust does not wash off during an ordinary rain. Chemical tests have indicated that enough sulfur remains, on the surface covered with either form, to prevent scab infection for twenty days of rainy weather. The reason for frequent applications during the early part of the season is, not to renew the coating on the surface, but to cover the new growth. During the period before blossoming, the apple tree frequently unfolds two or three new leaves in a day and the leaves that are already out increase rapidly in size. Later in the season, growth is much slower and less frequent applications are required.

It is obvious, from a study of the life history of the scab fungus, that the most dangerous period is from the time when the fruiting bodies in the old fallen leaves are ripe, until all their spores are shot. This period is usually from the time of the delayed-dormant spray until a month after the petal-fall application. If the new growth of leaves and fruit has been protected through the rain periods until there are no more spores from the dead leaves, special applications directed against scab are not needed for the rest of the season. On the other hand, if the trees have gone through a single rain infection period without protection and many of the leaves have become infected, later spraying or dusting will not insure a clean crop no matter how frequently it is done.

It is evident that the success or the failure to control scab is almost entirely dependent on the proper timing of thorough applications in the early part of the season. If an application is not made until after a long rain infection period, failure is almost certain. On the other hand, if an application is made a number of days ahead of the rain period, new growth will develop in the meantime which will be unprotected during the rain. For best results, the spray should be applied just before the rain period.

In western New York, the delayed-dormant spray was of importance

in scab control in eighteen of the past twenty-eight years.¹ Observations for a sufficient number of years are not available to determine the relative value of this spray in the Hudson Valley. The limited data indicate a somewhat later development of the scab fungus in relation to the fruit-bud development in those areas. Apparently the delayed-dormant spray is of importance in scab control there in fewer years. This does not mean, however, that this spray may be safely omitted in any part of the State.

The proper timing of the delayed-dormant spray is a very difficult problem. To provide for this, it is necessary to know (1) the stage of development of the scab fungus in the old fallen leaves, (2) the weather forecasts, (3) the development of the apple buds, and (4) the development of the apple aphids, which are controlled by nicotine in this spray. The increasing use of dormant and green-tip sprays for aphid control allows more latitude in timing this spray for scab control. The spray information service of the farm bureaus has been able to ascertain these factors and to properly time the delayed-dormant application. Many growers, however, apply the material before the spray-service warning, and they get poor scab control and no control of the aphids. No exact rule can be given, but usually the leaves of the blossom buds are out from $\frac{1}{4}$ to $\frac{1}{2}$ inch when this application is made. In some years serious sepal infection may occur even before this stage of the buds.

The pre-blossom application or applications, made between the delayed-dormant period and the bloom, present a still more difficult problem. An application during this period is almost always of importance in scab control. Two pre-blossom applications between the delayed-dormant spray and the bloom may be of value in some years. The important consideration in timing the pre-blossom treatment are (1) the weather forecasts, (2) the amount of growth since the last application, (3) the development of the apple buds, and (4) the development of the fruiting bodies of the fungus in the fallen leaves. It is essential to have as reliable a weather forecast as possible, preferably for three days ahead. If much new growth has occurred since the delayed-dormant period, and rains are coming, a cover must be applied even though only a few days intervene. If the clusters of fruit buds are exposed and the bud stems are elongated when the application is made, adequate protection will probably be secured through the blossoming period. On the other hand, if the application is made because of approaching rain when the buds in the cluster are still short-stemmed and closely packed together, a second application will be necessary just before the bloom, to give protection until the petal-fall application. In general, the practice is to delay the

¹From an unpublished thesis by W. D. Mills, *The Seasonal Development of Apple Scab in Western New York*.

application after the delayed-dormant period as long as the weather permits with safety, so that only one pre-blossom application will be made, as close to blossoming as possible. Many growers have failed to control scab because they waited for the full pink stage of the blossom buds, instead of timing the treatments to precede the rain periods.

The calyx application is made as the last of the petals are falling, and is timed by tree development alone. It is usually important in scab control.

A spray is advisable, in most seasons, about ten days after the calyx spray. This is necessary when there are still many scab spores in the old fallen leaves and rains are predicted.

The seasonal control of apple scab thus consists of a delayed-dormant treatment, one or sometimes two pre-blossom applications, a calyx application, and in most years a scab spray about ten days after the calyx application. A fungicide included in the later applications for apple maggot and codling moth is ordinarily sufficient for scab control during the summer.

For these applications, 2 gallons of lime-sulfur is used in each 100 gallons of the spray mixture, in combination with an arsenical for the control of chewing insects, and, when necessary, with nicotine for the control of insects for which the stomach poison is ineffective. Both calcium arsenate and lead arsenate are known to increase somewhat the fungicidal value of the spray against scab. Hydrated lime at the rate of 1 pound for each pound of lead arsenate should be added to the mixture. Lime-sulfur has been found more effective than the milder substitutes in checking the spread of scab from scabby leaves already present on the trees.

Wettable-sulfur sprays also are used for scab control. The manufacturers' directions should be followed. When homemade wettable sulfur is employed, $11\frac{1}{2}$ pounds of the material should be used in each 100 gallons of spray, in combination with the necessary insecticides. (See page 87.)

When dust is preferred, 90-10 sulfur-lead-arsenate dust is generally used. The dust should be of such fineness that 90 per cent or more will pass through a screen with 325 meshes to the inch. Where less arsenical is required, 95-5 sulfur-lead-arsenate dust is used, and in some cases straight dusting sulfur with no arsenical is employed. With the last-mentioned material, some "fluffer" or filler should be included to prevent agglomeration of the particles in a substance which will not dust well.

BUD MOTH*(Spilonota ocellana Schiffermüller)*

The bud moth has always been present in small numbers in most orchards of the State but was regarded as a minor pest until 1928, when a severe outbreak occurred in western New York. More recently it has increased in abundance in certain orchards of the Hudson Valley but has not caused important damage in this area.

The species passes the winter as small, half-grown larvae in inconspicuous silken cocoons covered with bits of bark and frass and fastened in the crotches of the twigs and around the buds of the smaller branches. These partly grown larvae emerge early in the spring, burrow into the opening fruit buds, and feed on the contents. As the buds expand, the larvae web together the unfolding leaves and feed inside the protecting nest thus formed, injuring both foliage and blossoms. They also gnaw into newly formed fruits and cause them to either drop or develop scars somewhat similar to those caused by the leaf-roller. The injured foliage of the nest turns brown, giving the tree the appearance of having been scorched by fire. The larvae sometimes bore into the terminal shoots, causing the tips to die back.

The larvae, which are chocolate brown with head and cervical shield black, become full-grown in late May or June and pupate within the nests. The small, ash-gray moths, with white markings, are present in the orchard from the middle of June until August. Soon after emerging, the female moths deposit on the leaves their milky white, flat, disk-like eggs, which except for their smaller size, closely resemble those of the codling moth. The eggs hatch in about a week, and the young larvae feed on the underside of the leaves, skeletonizing them in patches along the midrib and the larger veins and covering their feeding ground with a web of silk. Often, where an infested leaf rests against the surface of an apple, the larvae will eat out a group of small cavities, resembling codling-moth "stings" in the surface of the fruit. In badly infested orchards a large proportion of the crop may be injured in this manner.

In September the half-grown larvae desert the leaves and crawl to the branches, where they form their winter cocoons.

Control

The control of bud moth depends on the thorough application, year after year, of the regular schedule of sprays recommended for the control of rosy aphid, scab, and codling moth.

It has been proved that nicotine sulfate in the green-tip or delayed-dormant spray is the important factor in bud-moth control. Nicotine sulfate is usually included at the rate of 1 pint for each 100 gallons of the

spray mixture for the control of rosy aphid; where bud moth also presents a problem, nicotine sulfate should never be omitted.

If the grower is using tar-distillate emulsion for aphid control and desires to keep down the infestation of bud moth as well, the mixture should contain 3 per cent of creosote oil. If the bud-moth infestation is moderate or severe, a mixture containing 4.5 per cent of creosote oil should be used. (See table 2, page 96.)

CASE-BEARERS

Cigar Case-Bearer (*Coleophora fletcherella* Fernald)

Pistol Case-Bearer (*Coleophora malivorella* Riley)

The cigar case-bearer and the pistol case-bearer are commonly found on the apple throughout the State. They seldom become serious pests in well-sprayed orchards, but often are very abundant and destructive in neglected or poorly sprayed plantings.

Control

Case-bearers are usually held in check by the lead arsenate in the regular schedule of sprays. The pre-blossom sprays are especially effective, and, where case-bearers are causing injury, particular attention should be given to a thorough spray containing lead arsenate when the blossom buds are in the closed-cluster stage.

SCALE INSECTS

The three most important scale insects that attack the apple are the San José scale, the oyster-shell scale, and the scurfy scale.

The insect under the scale is a degenerate, soft-bodied creature. The scale is composed of secreted wax and the skins shed by the insect during its development. The three species mentioned differ markedly in the size, the shape, and the general appearance of the scale. The young scale insects, for a short time after birth or hatching, as the case may be, have legs and eyes, and move about in search of a suitable place for feeding. They then insert their thread-like mouth-parts into the plant tissue and begin sucking out the juices. Soon after settling down, they develop scales, lose their legs, and all except the males remain stationary for the rest of their lives.

San José scale

(*Aspidiotus perniciosus* Comstock)

In recent years the San José scale has increased considerably in abundance, especially in the older orchards, and in many orchards enough of the fruit has been spotted by the scale to hinder the sale of the crop.

In addition to the apple, the San José scale attacks pear, quince, peach, plum, and sweet cherry, but it rarely does any considerable damage to these fruits. Currants are especially subject to heavy infestations.

This scale attacks all parts of the tree, including trunk, branches, leaves, and fruit. When the insects are numerous, they gradually kill the limbs and the branches. On infested fruit, reddish rings develop around the spots where the scales are attached. These are more commonly grouped about the blossom end. Badly infested fruit is considerably discolored, and sometimes is stunted and misshapen.

The scale of the full-grown female is round, about the size of a pin-head, and grayish in color with a central dark spot. In bad infestations these scales are crowded together and resemble a grayish, roughened, scurfy deposit on the bark. The scales of the young insects are smaller than those of the adult, and are black.

Although the insects are present in all stages on the trees in the fall, all perish during the winter except a small proportion of the partly grown young. These complete their development in the spring, and the mature females begin to give birth to living young in the latter part of June. In a cool season with a late spring, the scale does not begin to breed until late, and under these conditions only one full brood and a partial second brood are able to develop before cold weather. Each female gives birth to between 100 and 200 young. The pest can multiply rapidly when conditions are favorable.

Control

In many orchards it is unnecessary to make special applications of oil or strong lime sulfur each year for scale control. The scale is, however, a constant menace and should be watched closely; when it begins to increase in an orchard steps should be taken to control it promptly. The most efficient treatment for San José scale is a lubricating-oil emulsion containing 3 per cent of oil applied as a dormant or green-tip application. The cheapest spray for this purpose can be made up by the grower in the spray tank, by using 3 gallons of lubricating oil and $\frac{1}{2}$ pound of lignin-pitch emulsifier (see page 94). Commercial miscible oils may also be used; these preparations should be diluted according to manufacturers' directions.

Tar-distillate emulsions are not effective against the San José scale except when they contain petroleum oil, and then their efficiency against this insect depends on the percentage of petroleum oil present. If it is desired to control both aphids and San José scale with one application, one may purchase a commercial product containing tar oil and petroleum oil in such proportion that they can be used for both insects.

A common mixture of these two oils contains 37 per cent of tar oil and 46 per cent of lubricating oil. A preparation of this kind should be used at the rate of 6½ gallons and water to make 100 gallons. Strengths higher than this are not advised because of injury to the trees. If the trees are in a weakened condition, or if for any other reason, the grower does not wish to use an oil spray, San José scale can be controlled by spraying with 11 gallons of lime sulfur and water to make 100 gallons of spray.

Oyster-shell scale

(*Lepidosaphes ulmi* Linnaeus)

The oyster-shell scale is sometimes abundant enough on neglected apple trees to weaken the trees and even to kill the branches, but it is of no importance in well-sprayed commercial orchards. It is more likely to be troublesome in the cooler climate of the northern counties of the State. It is not nearly so dangerous as the San José scale, because there is only one generation a year and the species is much less prolific. The mature female scale is about ⅛ inch long and closely resembles an oyster shell in form. This species winters over in the egg stage beneath the old scales, and the young hatch in May or June.

Control

The oyster-shell scale is rarely present in injurious numbers in well sprayed orchards. It is best controlled by spraying with tar-distillate emulsion containing 4.5 per cent of tar oil in the diluted mixture. Light infestations of oyster-shell scale may be held in check by using a 3-per-cent mixture. (See table 2, page 96.)

Scurfy scale

(*Chionaspis furfura* Fitch)

In recent years the orchards in a restricted area on the east side of the Hudson River have become heavily infested with the scurfy scale. The full-grown female scale is about ⅛ inch long, and is flat, pear-shaped, and grayish-white in color. There are two generations of the insect annually. When the insects are numerous, they give the bark a scurfy appearance and in many cases the fruit is spotted in a manner similar to that caused by San José scale.

Control

The scurfy scale can be controlled by spraying with a tar-distillate emulsion containing 4 per cent of tar oil in the diluted mixture. One of the combination tar and lubricating-oil emulsions having a total tar and

lubricating-oil content of 5 per cent may be used. This concentration should also give some protection against San José scale.

A 6-per-cent lubricating-oil emulsion may be used to control San José scale, scurfy scale, and leaf-roller. The lubricating oil also gives some protection against aphids.

All of these oils should be applied as a dormant application in the spring before the buds show any green at the tips.

FRUIT-TREE LEAF-ROLLER (*Cacoecia argyrosipila* Walker)

Until a few years ago the fruit-tree leaf-roller was practically unknown as a pest in the Hudson Valley. It is now present in destructive numbers in several orchards in this region.

This insect passes the winter in the egg stage. The eggs are usually laid on the smaller twigs and on the fruit spurs, in small, oval, flat, grayish or brownish patches, about $\frac{1}{4}$ inch in diameter and containing, on the average, about 55 eggs. The egg masses are protected by a smooth, varnish-like substance, which so closely resembles the bark in color that the unhatched masses are difficult to detect. Hatched egg masses are more conspicuous; the exit holes of the larvae in the bleached white varnish suggesting a colander, or strainer.

The eggs normally start hatching when the blossom buds of McIntosh apples are showing pink. Individual egg masses usually complete hatching within a few days, but the hatching period for the whole brood extends over a period of about ten days, depending on the season. The young caterpillars are about $\frac{1}{16}$ inch in length, and are of a light green color with the head and the cervical shield black.

The caterpillars cause several types of injury. The first indication of their presence is the "ragging" of the leaves at the tip of the terminal



FIGURE 4. SCURFY SCALE ON APPLE TWIG
One scale has been turned back to show the eggs
(Greatly enlarged)

shoots (figure 5). The extent of this type of injury is a good indication of the number of leaf-rollers present and the danger of fruit injury.

At blossoming time the caterpillars web together the leaves and the



COURTESY OF S. W. HARMAN

FIGURE 5. "RAGGING" OF TERMINAL FOLIAGE OF APPLE CAUSED BY THE LEAF-ROLLER

blossom buds of the opening clusters, and feed within the nest thus formed, often destroying large numbers of blossoms by chewing off the stems. As the young fruit is forming, the caterpillars first devour the calyx lobes and later eat out large, irregular holes in the fruit. The most seriously injured fruits soon drop, while those less severely injured remain on the tree but bear large, brownish, corky scars which render them misshapen and unmarketable (figure 6). Although the injury to



FIGURE 6. FRUIT INJURED BY THE FRUIT-TREE
LEAF-ROLLER

the fruit itself is the most conspicuous damage caused, the destruction of fruit buds and foliage also may be severe.

The caterpillars are often found resting in rolled leaves adjacent to fruit, or in nests containing injured fruits and leaves webbed together. When disturbed, they escape with a rapid, wriggling motion and spin down on a thread of silk.

The caterpillars become full-grown in three to six weeks and are then about 1 inch in length. They transform to brown pupae within a rolled leaf, and in about twelve days emerge as moths. The moths have a wing expanse of $\frac{3}{4}$ to 1 inch, and the front wings are mottled with various shades of rich brown and yellowish white.

The moths begin egg-laying soon after emergence, and most of the eggs are laid by the last of June. The eggs do not hatch, however, until the following spring, and so there is only one brood each year.

Control

The fruit-tree leaf-roller is not satisfactorily controlled by the regular schedule of sprays, and special control measures are necessary wherever the insect is causing enough damage to warrant their use.

The leaf-roller can be attacked in either the egg or the caterpillar stage. The eggs are susceptible to oil sprays, and the caterpillars to heavy applications of lead arsenate. In severe infestations it is desirable to use both methods of control.

Arsenical sprays

The control of leaf-roller by means of arsenicals requires the use of extra sprays and heavier dosages of lead arsenate than are included in the regular schedule. With light infestations, injury from this insect can be largely prevented by increasing the amount of lead arsenate in the regular pre-blossom and calyx sprays to 6 pounds in 100 gallons of the spray mixture, and spraying very thoroughly. The exact time of application will depend somewhat on the seasonal variations and the time of hatching. In some seasons the pre-blossom spray is the important one; other years it is the calyx spray.

With heavier infestations, the lead arsenate should be used at the rate of 6 pounds in the pre-blossom, calyx, and curculio sprays.

The young, newly hatched larvae are much more susceptible to poison than when they are older, and the object of spraying is to keep the rapidly developing new foliage covered with poison throughout the hatching period.

Oil sprays

Severe outbreaks of leaf-roller are best controlled by an effective oil spray to kill the eggs before they hatch in the spring, followed by applications of lead arsenate as previously indicated. The efficiency of the oil spray is extremely variable, depending on the type of oil used, the time of spraying, and the thoroughness of application.

Commercial or proprietary miscible oils are variable in efficiency. The results of numerous tests in New York and other States indicate that, at recommended strengths, some brands are effective while others are practically worthless. Some are ineffective even at greatly increased strengths. If commercial miscible oils are used, it is best to follow the directions of the manufacturer.

Commercial lubricating-oil emulsions, in general, give satisfactory control. Some brands contain about 66 per cent of oil and should be used at the rate of 9 gallons to 100 gallons of the spray mixture.

Homemade tank-mixed lubricating-oil emulsions are effective, safe, and considerably cheaper than most of the commercial oil preparations.

Lubricating oil is used at the rate of 6 gallons to 100 gallons of the spray mixture. This is readily mixed in the spray tank according to directions given on page 94. It is important that the spray material be kept violently agitated in the spray tank.

Whatever the type of oil used, it should be applied as the buds are swelling but not after green tissue has begun to show at the tip. If applied later it is very likely to cause injury, and if applied earlier it is less effective against the eggs, since these become progressively more susceptible as they near the hatching stage.

Oil sprays, to be effective, must be very thoroughly applied, with plenty of pressure and not too fine a spray. Large trees should be sprayed from both the tank and the ground, for only those egg masses are killed that are thoroughly covered with spray. Contrary to general opinion, oil sprays do not spread to any extent after being applied. Special care should be taken to cover the tree evenly and not to overspray the lower limbs. Excessive spraying with 6-per-cent oil is likely to kill the buds, especially on weakened trees.

Even with very careful spraying and the most effective materials, some of the egg masses escape and give rise to a considerable number of larvae. In orchards where the egg-masses are extremely abundant, oil sprays alone cannot be relied upon for control because, if only 1 or 2 per cent of the egg-masses escape, enough larvae will hatch to ruin the crop. The oil spray should be followed by thorough applications of the increased dosage of 6 pounds of lead arsenate in the pre-blossom and calyx sprays, to kill these young caterpillars.

GREEN FRUIT-WORMS

Xylina grotei Riley

Orthosia hibisci Guénée

Xylina antennata Walker

Xylina laticinerea Grote

Green fruit-worms are rather large apple-green caterpillars with a narrow cream-colored stripe down the middle of the back, with a wider stripe along each side, and between the two an indistinct stripe is often present. Green fruit-worms attack apple, pear, and to a less extent other orchard fruits. They are found also on various forest trees, notably poplar, soft maple, hickory, and wild cherry. They vary greatly in abundance from year to year; outbreaks in New York have occurred in 1877, 1896, 1913, and 1933.

The moths of the green fruit-worms appear on the trees in March or April and deposit their eggs singly on the bark of the smaller branches. The young larvae feed on foliage or buds and are about half-grown by

the time the fruit is set. The caterpillars do not bore into the fruit but usually begin feeding on one side and may continue till the young apple is nearly half consumed. They go from fruit to fruit, ruining one after another. The scars caused by the green fruit-worms are similar to those of the leaf-roller but usually are not so deep. Most of the caterpillars become full-grown by the first week in June. They then go into the ground for pupation. There is only one generation a year.

Control

Fortunately, the green fruit-worm is not so difficult to control as is the leaf-roller. The larvae feed more openly and are more sensitive to poisons. Thorough spraying in the pre-blossom and calyx applications with 3 pounds of lead arsenate will usually hold the pest under control. When they are abundant, great care should be taken to make this application on time.

APPLE-TREE TENT-CATERPILLAR

(*Malacosoma americana* Fabricius)

Although in years of abundance the apple-tree tent-caterpillars may defoliate neglected and unsprayed apple and peach trees, they are never of importance in well-sprayed orchards.

Control

The caterpillars hatch as the buds are opening. Lead arsenate at the rate of 3 pounds in 100 gallons of the spray mixture, included in the delayed-dormant spray, gives excellent control.

EUROPEAN RED MITE

(*Paratetranychus pilosus* Canestrini & Fanzago)

The European red mite passes the winter in the egg stage on the under surface of small branches of trees, in crevices and crotches of fruit spurs, and on roughened areas on the bark of the larger limbs and the trunk. The eggs are small, spherical, and reddish in color, and when numerous they resemble a coating of brick dust. Usually they begin to hatch when the blossom buds first show pink, and have completed hatching by the time the petals have fallen. The newly hatched mites crawl to the leaves and begin to feed. They feed mainly on the underside of the leaves, piercing the surface with their thread-like mouth-parts and sucking out the plant juices.

When the mites are numerous, they cause the leaves to turn yellow and sometimes to fall prematurely. Baldwin and Delicious are the varieties most commonly attacked.

Control

Red-mite eggs are readily killed by spraying with a 3-per-cent lubricating-oil emulsion or with miscible oils at the usual strength.

Although lime-sulfur has little effect on red-mite eggs, it is effective against the mites themselves. When lime-sulfur is used in pre-blossom and calyx sprays, a large proportion of newly hatched mites are killed before they have begun to lay eggs.

Wettable sulfurs and sulfur dusts have very little effect on red mites; and where these materials are used in place of liquid lime-sulfur, especially in the pre-blossom and calyx applications, the species is likely to become troublesome.

If for any reason the mite becomes alarmingly abundant in the summer, the attack may be checked by spraying with summer-oil emulsion, 1 per cent actual oil, provided sulfur fungicides have not been applied within a month. Some sulfur preparations adhere for a long time and there is danger of burning from the use of summer oils if a sulfur residue is visible on the foliage. The use of oil at this late season may be objectionable in that it will cause residue already present to adhere more tightly to the fruit.

CODLING MOTH

(*Carpocapsa pomonella* Linnaeus)

The codling-moth caterpillar is, on the whole, the most serious pest of apples in New York. Not only does it cause practically all of the familiar wormy apples which are almost a total loss to the grower, but it also produces serious damage in the form of stings, or small shallow cavities, which throw affected apples out of the better grades.

The species passes the winter as full-grown larvae in tough silk cocoons lining small cavities beneath flakes of bark on the tree, in crotches, crevices, and pruning scars on the trunk, and in dead, punky twigs, sticks, and débris on the ground. Numbers of the larvae winter over in crevices in the floor, the siding, and the bins of packing houses, cider mills, or other places where apples have been stored at picking time. The larvae are pinkish or whitish in color, and about $\frac{3}{4}$ inch in length. With the advent of warm weather in the spring, the larvae transform inside their cocoons to brownish pupae about $\frac{1}{2}$ inch long. They remain in this stage from three to four weeks and then change to moths. The moths have a wing spread of about $\frac{3}{4}$ inch. The front wings have the general appearance of watered silk, and are marked near the tip with a coppery brown spot bounded on the inside by a chocolate-colored band. The moths are active mainly throughout the twilight period on warm evenings. They are not strong flyers, the majority settling down within 200 to 300 feet of the place of emergence.

The first appearance of the moths and the length of the emergence period are influenced by seasonal temperature, and therefore vary some-

what from year to year. The emergence of first-brood moths extends over a period of about six or seven weeks, beginning shortly after the petals have fallen and reaching a peak about four weeks later. The early moths come from cocoons in warm, sheltered situations. Some of the moths from buildings and packing-houses may emerge from one to three weeks later than does the brood in the orchard.

The female moth deposits her flat, disk-shaped, scale-like eggs on the leaves and on the surface of the fruit. The eggs are smaller than a pin-head, are whitish in color, and are almost transparent at first but later show a reddish ring, and, just before hatching, a black spot, which is the head of the larva.

Temperature and weather conditions have a very important effect on egg-laying. The moths are active in egg-laying only on clear evenings when the temperature ranges above 60° F. If the weather is favorable, the moths begin to lay eggs within three or four days after emergence. With continued favorable weather, egg-laying starts about a week after the petals have fallen and is heaviest about four weeks later, or soon after the maximum emergence of moths. Periods of cool or stormy weather may delay the start of egg-laying or interrupt it for a time, so that the egg-laying and egg-hatching periods may be irregular in some years.

The time required for the eggs to hatch depends somewhat upon the temperature, but it averages about a week. The newly hatched caterpillars are about $\frac{1}{16}$ inch in length. Caterpillars hatching from eggs on the leaves often crawl to the underside of the leaves and feed slightly before proceeding to the fruit. Caterpillars hatching on the fruit usually begin at once to search for suitable places to enter.

Many of the early-hatched caterpillars of the first brood enter through the calyx cup, or blossom end, of the fruit. If they are not killed by poison in the calyx cup, they eat their way to the core. The greater number of the later-hatched caterpillars enter the fruit through the side. They prefer to enter either where an apple touches another fruit or a leaf, or where an insect injury, a puncture, or a russeted area makes entrance easier. Many of these "side-worm" caterpillars cause a type of injury known as *codling-moth sting* (figure 7). A sting results when a larva, after having eaten out a shallow



FIGURE 7. CODLING-MOTH STINGS
AND SIDE ENTRANCES

cavity under the skin, either finds the food unpalatable and deserts the burrow to try another point of entrance, or dies from the effect of the poison that it has obtained while making an entrance. A few of the first-brood larvae, entering the side of the fruit late, find the apple sufficiently developed and burrow directly to the core:

The time spent by the larvae in the fruit varies considerably, but averages about thirty days for the first brood and three weeks for the second. When nearly full-grown, the larvae burrow to the surface and keep the opening plugged with excrement until they are ready to leave the fruit. The full-grown larva is about $\frac{3}{4}$ inch in length, and is pinkish white in color with the head dark brown and the thoracic and anal shields lighter brown.

The greater number of the first-brood larvae leave the fruit before it falls, and crawl down the branches until they find a suitable place for spinning a cocoon. A considerable proportion of the larvae from fallen fruit spin their cocoons in sticks and débris on the ground. After making the cocoons, the larvae may do one of two things; they may remain in the larval condition until the following spring, or they may change to pupae in about a week. In the latter case these summer pupae transform in about ten days to a brood of moths which lay eggs for the second generation.

In New York, only some of the larvae spinning cocoons before August 1 transform in the same season, and practically all the larvae that become mature after that date hibernate. The abundance of the moths of the second brood depends on the forwardness or the backwardness of the season. If May or June is backward, egg-laying will be delayed so that very few codling-moth caterpillars will have reached maturity by August 1, and consequently very few moths will be produced in that season. If, on the other hand, May or June is early, a greater proportion of the caterpillars will become full-grown before August 1, and the number of the second-brood moths will be considerably greater. A larger proportion of second-brood caterpillars enter the fruit at the side than is the case with the first brood, and most of these burrow directly to the core. Only a small proportion of them cause shallow stings like those made by the first brood.

Control

The first spray for the control of the codling moth, using 3 pounds of lead arsenate to each 100 gallons of the spray mixture, should be applied when the last of the petals are falling. The poison applied at this time is retained in the calyx cavity and will kill codling-moth larvae attempting to enter this point in the fruit later in the season. The complete formula for this application is given on page 8.

First codling-moth cover spray (About June 10 to 15)

The formula for this application is given on page 9.

To protect the fruit from codling moth attack during the remainder of the season, two or more cover sprays are required. Beginning with these applications it is very difficult to obtain satisfactory protection without having too much residue on the fruit at harvest time.

The following suggestions are offered for those growers who desire to obtain adequate insect control without the necessity of removing spray residues by washing the fruit. However, no guarantee may be given that any of the suggestions offered will provide entirely satisfactory control or freedom from spray residues.

Second codling-moth cover spray or first apple-maggot spray (About June 25 to July 1)

For varieties ripening after McIntosh, lead arsenate may be used.

The formula for this application is given on page 10.

For McIntosh and other early varieties, it is suggested that calcium arsenate be used to lessen the danger of spray residue.

The formula for this application is given on page 10.

Third codling-moth cover spray or second apple-maggot spray (About July 15)

To prevent excessive spray residues, the use of calcium arsenate is suggested at this time for all varieties.

The formula for this application is given on page 10.

In any of the cover sprays where calcium arsenate is used, the following points should be kept in mind:

It has been found that calcium arsenate is less effective than lead arsenate against the codling moth. In moderately infested orchards, however, good commercial control results from its use.

An important objection to the general use of calcium arsenate is the danger of serious foliage injury. The incidence and severity of this type of injury apparently depends on a number of factors, such as the variety of apple, the vigor of the tree, weather conditions, and the other ingredients of the spray mixture.

A grower should select a type of calcium arsenate which is stated by the manufacturer as being suitable for use on fruit trees. It should never be used alone; 3 pounds of hydrated lime should be added to the spray mixture for each pound of calcium arsenate used. This addition of lime may prevent the foliage injury, or may merely postpone it for a time. The danger of injury seems to be less when the calcium arsenate is used with wettable sulfurs. McIntosh, Wealthy, and Rome apples seem to be less liable to injury than do other common varieties; Baldwin, Rhode

Island Greening, and Ben Davis are especially susceptible to injury. Weak trees show more injury than do vigorous ones. Different brands of calcium arsenate vary greatly in quality; some are much safer to use than others. Calcium arsenate is likely to deteriorate if held over for the following year; it is less likely to cause injury if recently manufactured. In view of these facts it would seem advisable to limit the use of calcium arsenate to the last one or two treatments for the season. In spite of all its limitations, calcium arsenate is the best substitute available for lead arsenate in those areas where the codling moth is not an acute problem.

Sprays for second brood of codling moth

In a few orchards it may be found necessary to protect the fruit from second-brood codling larvae in early August. For this purpose one of the so-called fixed nicotine preparations may be tried. (See page 91.)

It can be readily seen that, since the timing of the cover sprays depends on the time of egg-hatching, and since these dates are different for different counties and vary somewhat from year to year in the same locality, it is very important to have reliable information on the seasonal development of the codling moth. In most of the counties where fruit is grown extensively, this information can be obtained through the local farm-bureau spray information service.

The cover sprays must be applied thoroughly as well as at the right time. The first cover spray is especially important in the Hudson Valley and growers would do well to take pains to time it accurately and to apply it well. The fruit and the foliage should be well covered with the poison. If this is done, many of the caterpillars hatching on the leaves will be poisoned before they are able to reach the fruit. Caterpillars reaching the fruit and those hatching on the fruit will be killed while entering it. In badly infested orchards these sprays will not entirely prevent stings, since some of the caterpillars will be able to eat out a shallow hole before they die from the effects of the poison. But thorough spraying year after year will reduce the number of moths in an orchard. For this reason, even light crops of fruit should be thoroughly sprayed and not allowed to become wormy.

APPLE REDBUGS

Bright Apple Redbug (*Lygidea mendax* Reuter)

Dark Apple Redbug (*Heterocordylus malinus* Reuter)

Redbugs are important pests of the apple throughout the Hudson Valley. The infestation is seldom general in any fruit district, being usually confined to occasional orchards or to certain varieties of apples. While any variety may be attacked, McIntosh, Rhode Island Greening, and Northern Spy are especially susceptible to injury.

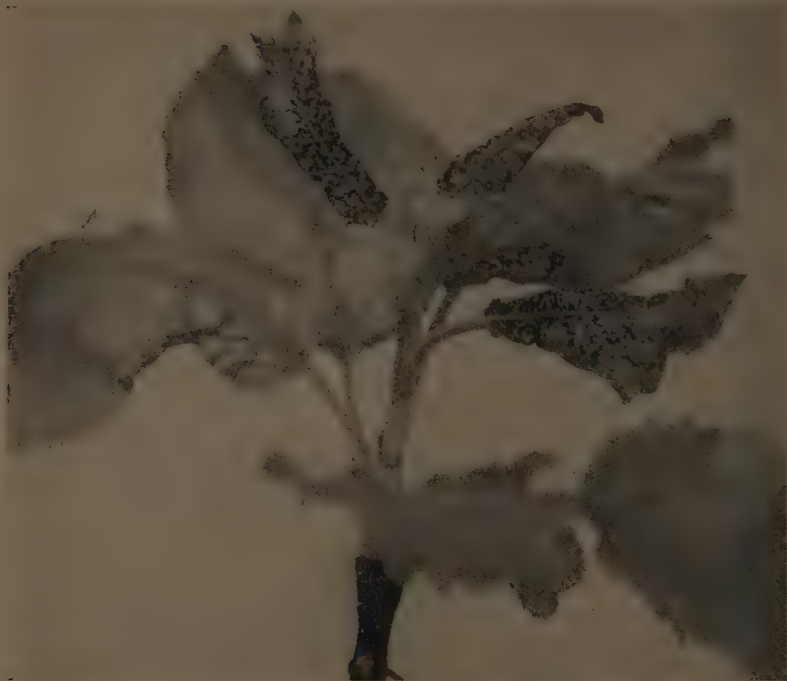


FIGURE 8. FOLIAGE INJURED BY THE REDBUG

The two species of redbugs, the bright apple redbug and the dark apple redbug, are closely related and resemble each other in habits and life history. The bright apple redbug is by far the more abundant and injurious of the two, and practically all of the serious commercial damage is caused by this species.

Both species pass the winter in the egg stage in the bark of the smaller branches of apple trees. The eggs of the bright apple redbug begin to hatch when the earliest blossoms show pink, and continue hatching through the blossoming period.

The newly hatched nymphs are about $\frac{1}{16}$ inch in length. The nymphs of the bright apple redbug may be distinguished by their brighter red color, by having the body covered with fine, short, black hairs, and by the lack of dusky markings on the thorax. Both species pass through five immature stages and develop wings at the fifth molt.

The newly hatched nymphs at once attack the tender young leaves of terminal shoots and the new growth on lateral shoots and spurs (figure 8). By means of their bristle-like mouth-parts they pierce the leaf tissue

and suck out the plant juices. Injured leaves soon develop clusters of conspicuous reddish dots marking the feeding punctures of the nymphs. These injured tips are often the first indication of the presence of redbugs in an orchard. The insects themselves are very wary and difficult to detect among the unfolding leaves. The nymphs may live on the foliage until they are full-grown, but they usually leave the shoots to attack the fruit soon after it has set. When very young fruit is attacked, the bristles of the bugs penetrate to the core. Many of the injured fruits fall to the ground. Those that remain become gnarly and deformed, owing to the fact that the punctured spot fails to develop, while the surrounding fleshy tissue grows out around it, forming a deep pit with the puncture at the center extending as a hard, corky line to the core (figure 9). Punctures made later, after the fruit has become too large for the insect to reach the core, may develop either into shallow pits or into peculiar irregular, russeted areas. The adults of both species feed to some extent on both the fruit and the foliage, and deposit their eggs during June or July.

Knotty apples are caused also by curculio punctures and by aphid injury. Redbug injury may be distinguished from the injury caused by the plum curculio by the fact that no tissue is removed; the juice is merely sucked out, causing a smooth depression in the fruit. The feeding and egg-laying punctures of the curculio cause characteristic scars. Aphid injury is characterized by a puckering about the blossom end of the fruit, which does not appear in typical redbug injury.

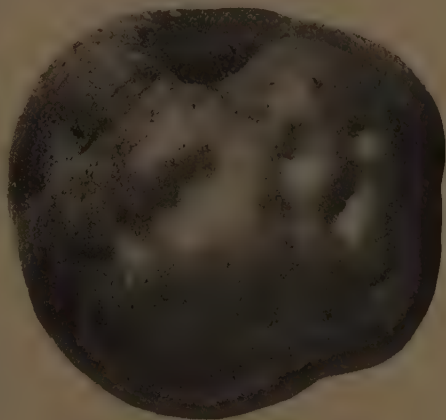


FIGURE 9. AN APPLE SHOWING TYPICAL REDBUG INJURY

Control

The most practical method of controlling redbugs is by the use of nicotine sulfate, 1 pint in 100 gallons of the spray mixture, added to the calyx spray.

In spraying for redbugs the utmost thoroughness is necessary. Care should be taken to reach the growth in the center of the tree. The tree should be sprayed from within as well as from without. The insects are killed only when the spray actually hits them or drenches the foliage in

the immediate vicinity. To be effective, the spray should be applied on a warm day, when the young bugs are more active; in cool weather they often secrete themselves in the curls of the unopened leaves, where it is impossible to reach them. The spray is most effective when applied at petal-fall time when the redbugs are in the early stages, but in emergencies this pest may be kept in check by a spray applied within a week after the regular time for making the calyx application. If the infestation is heavy, and a drenching application is necessary, it will be advisable to substitute a wettable sulfur for the liquid lime-sulfur as the fungicide, to reduce the danger of spray injury.

THREE RUST DISEASES OF THE APPLE

Apple Rust (*Gymnosporangium juniperi-virginianae* Schweinitz)

Hawthorn Rust (*Gymnosporangium globosum* Farlow)

Quince Rust (*Gymnosporangium germinale* (Schweinitz) Kern)

The three rust diseases of apple are caused by three fungi which live during a part of their lives on the red cedar and during the remainder largely on the apple, the hawthorn, and the quince, respectively.

Both the apple and the quince rust cause direct and serious losses by infections on the apple fruit, while the apple and the hawthorn rust are occasionally destructive on apple foliage. Both types of injury have been largely confined to the Hudson Valley, where red cedars are abundant. The bright orange-colored spots of the apple and hawthorn rusts on the apple leaves are very conspicuous; the hawthorn-rust spots are somewhat the smaller.

The apple-rust spots on the fruit are orange in color, and the small cups of the apple-rust fungus may be seen on the spots when mature. The quince-rust spots on the apple fruit are sunken and are dark green in color, and the tissue below the spots is killed. The small cups of the rust fungus are absent in fruit affected with the quince rust.

The apple rust and the hawthorn rust form their fruiting bodies on the red cedar in the form of cedar apples. These apples, or galls, of the two rusts are similar in appearance, but those of the apple rust are more regular in outline than those of the hawthorn rust, and the surface is covered with circular depressions much like those on a golf ball; the apples of the hawthorn rust are more irregular in form, and do not show the regular arrangement of circular depressions. When the cedar apples are wet in the spring, yellow gelatinous horns protrude from them, these being long and tapering in the case of the apple rust and shorter and more wedge-shaped in the case of the hawthorn rust. The quince rust does not form the galls, or cedar apples, on the cedar, but fruits in cankers on the twigs, the limbs, or the trunk of the cedar.

The apple rust has long been known as a serious disease of apple fruits, especially on the more susceptible varieties such as Wealthy. The quince rust is serious on such varieties as McIntosh, Delicious, and Winesap.

Control

The most effective control of cedar rust can be obtained by the eradication of all red-cedar trees within a radius of at least one-half mile from the orchard. One red cedar tree heavily infested with cedar galls is sufficient to infect an average-sized orchard. In most situations in the Hudson Valley cedar eradication seems impractical.

The application of fungicides is the most promising alternative. The most adhesive fungicides should be used. The fungicides must be applied thoroughly and before rain or infection periods. Heavier spraying is required than that usually employed for the control of scab. The apple rust may cause commercial damage on fruit and foliage any time within the period extending from the closed cluster-bud stage until the third week in June, and for fruit infection by the quince rust from the closed cluster-bud stage until the ten-day spray. Since new growth should be covered, it may be necessary to spray at about five-day intervals. An application during bloom may be essential. Correct timing for an effective spray program can be best obtained through the farm-bureau spray-information service during the critical period.

Lime-sulfur 1-50 is the most effective fungicide if the trees are not too weakened to withstand it. Frequency and thoroughness of application are more important than concentration of material. The wettable sulfurs containing the finest sulfur or having the greatest adhesive properties are about as effective as lime sulfur. Flotation sulfur pastes at 8 or 10 pounds to 100 gallons have given excellent control. Bentonite sulfur spray, 6 pounds in 100 gallons, has given promising results, particularly if the foliage is smooth or waxy and conditions are poor for drying, as during rainy weather. A heavy application of bentonite-sulfur dust may be valuable as a supplementary emergency measure, especially during periods of drizzly rain.

Conditions may be so favorable for rust in an orchard that the cost of control by fungicides is prohibitive; if cedar trees cannot be eradicated, the only alternative is to replant with resistant varieties.

BLACK ROT

(Caused by the fungus *Physalospora obtusa* (Schw.) Cooke)

Black rot attacks the bark and the leaves of the apple, as well as the fruit. On the bark the disease is called *black-rot canker* and *New York apple-tree*

canker. On the fruit it is called *black rot*, *ring rot*, *blossom-end rot*, and *brown rot*. On the foliage it is usually called *frog-eye*, although it is known also as *leaf spot* and *brown rot*.

This disease is of more importance economically as a leaf spot and as a canker than as a rot of the fruit. In this State, the varieties Baldwin, Rhode Island Greening, and Twenty Ounce show spotted foliage most commonly. Twenty Ounce is by far the most susceptible of all the varieties to the canker form, but Esopus Spitzenburg, Baldwin, Wagener, Rhode Island Greening, and Tompkins King also are susceptible to cankers.

In severe attacks of "frog-eye," defoliation may occur before harvest; in slight attacks the loss is negligible.

The annual loss of fruit in New York due to the death of cankered limbs from black-rot canker was estimated some years ago by a careful worker at not less than \$750,000. The area where this trouble has been most severe is that bordering Lake Ontario in western and central New York. There appears to be an increase in the amount of black rot developing on the limbs of apple trees in the Hudson Valley. The black-rot fungus is appearing in many orchards on the dead and injured wood which resulted from the severe injury the winter of 1933-34.

Control

For leaf spot, lime-sulfur has proved to be quite as effective as bordeaux mixture. Dusting with sulfur also is effective. Summer applications are effective against this disease, since most of the leaf infection occurs during the two or three weeks after the petals have fallen.

The effectiveness of applications of fungicides for canker prevention is not proved. However, the decided decrease of canker injury in the State since the general adoption of lime-sulfur spraying leads to the belief that these applications are of value. Systematic cutting-out of cankers and removal of mummied fruit are valuable methods of control.

PLUM CURCULIO

(*Conotrachelus nenuphar* Herbst)

(See also under *Plum and Prune*, page 81)

In parts of the Hudson Valley the plum curculio is one of the most serious pests of the apple. This is because the numerous stone walls, hedgerows, and woodlots adjoining the orchards serve as ideal winter quarters for the beetles.

The apples are injured by the feeding and egg-laying punctures of the adults and by the burrowing of the grubs. Many of the injured apples

fall to the ground, while those that remain on the tree develop D-shaped russeted scars (figure 10) and are often rendered knotty and unmarketable.

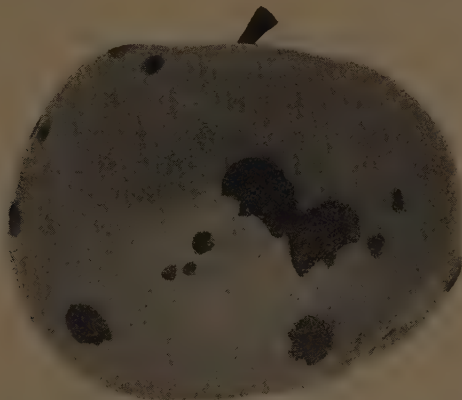


FIGURE 10. SCARS RESULTING FROM EGG-LAYING PUNCTURES MADE BY THE PLUM CURCULIO

The overwintered beetles begin to attack the fruit soon after it has set, and are capable of causing extensive injury in a very short time. Although both feeding and egg-laying may continue for a considerable period, egg-laying is most intensive during the first few weeks. The new generation of beetles, appearing in August, sometimes injure the fruit by their feeding punctures before going into hibernation.

Control

The calyx spray has some influence in reducing injury. In orchards where the pest is likely to be serious, however, chief dependence for control should be placed on the curculio spray applied about seven to ten days after the calyx spray, using 3 pounds of lead arsenate in 100 gallons of the spray mixture. This spray is usually combined with an application necessary in most years at this time for apple-scab control. The first cover spray for the codling moth, usually applied about three weeks after the calyx spray in the Hudson Valley, is of some value in controlling the curculio. Curculio injury is often localized in certain parts of an orchard near hibernating shelter. In such cases the special sprays may be applied only to that part of the orchard where they are needed.

APPLE MAGGOT

(*Rhagoletis pomonella* Walsh)

In the Hudson Valley and Lake Champlain regions, the apple maggot, or railroad worm, is one of the most serious pests of the apple and is

present in many orchards. All apple varieties may be attacked, but early-harvest and early-fall varieties are especially subject to injury. Of the late varieties, Fameuse, Jonathan, and Northern Spy are the most liable to attack. The apple maggot occasionally infests plums and prunes.

The adult of the apple maggot is a black-bodied fly slightly smaller than the house fly (figure 11). The transparent wings are crossed by four

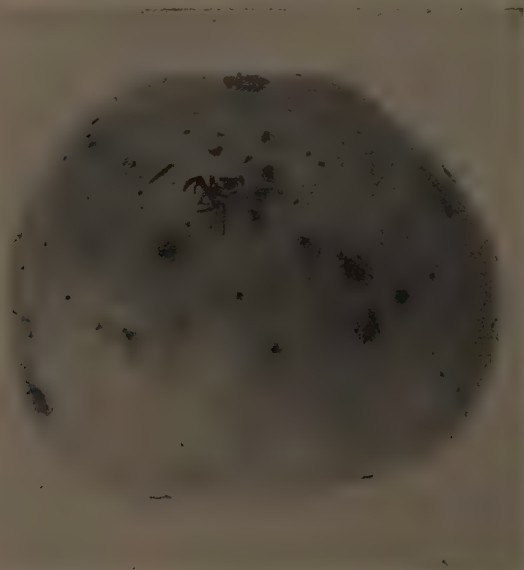


FIGURE 11. APPLE-MAGGOT FLY AND EGG-LAYING PUNCTURES

dusky bands. The thorax is black, with two fairly distinct white bands extending lengthwise and a white spot at the rear. The female is larger than the male, and has four white bands across the abdomen while the male has only three.

The flies begin to emerge from their overwintering puparia in the ground during the latter half of June. They continue to emerge until early August, and, since they may live for a month or longer, a few late-emerging individuals may be found in the orchard until early September.

The flies do not begin to lay eggs until a week or ten days after emergence. They are readily found on bright days, moving about and sucking up drops of moisture, gums, juices, or almost any material present on the surface of the leaves or the fruit. Particles of solid material are dissolved by means of saliva secreted through the mouth-parts of the flies.

The female deposits her minute whitish eggs singly, in the pulp of the

apple, through small punctures which she makes in the skin with her sharp ovipositor. A large number of eggs may be deposited in a single fruit, and fruits of late varieties become much dimpled and pitted as a result.

The eggs hatch in four to six days, and the young maggots begin at once to tunnel through the fruit in all directions. At first the track left by a maggot is faint, but, as the fruit begins to ripen and soften, the maggot grows rapidly and leaves a broad brownish trail. Badly infested fruits often fall to the ground early. The numerous tunnels reduce the inside of the fruit to a brownish, pulpy mass and render it unmarketable. Winter fruits in which eggs are laid late in the season may seem normal at picking time and later rot suddenly as a result of the work of the maggots after the fruit has begun to soften in common storage.

When full-grown the maggot is about $\frac{1}{3}$ inch long and is whitish or yellowish white in color. It emerges from the fallen fruit and burrows into the soil to the depth of 1 or 2 inches. Here it molts, but it remains inside the old skin, which then becomes a tough, brownish, protective case, known as the *puparium* and resembling a plump grain of wheat. Under exceptional conditions a few of the larvae may change to flies in the same year, but the greater number remain as pupae until the following summer and a few may remain in this condition until the second season.

Control

The most practical and effective method of control consists in spraying with lead arsenate, 3 pounds in 100 gallons of the spray mixture, to kill the flies before they can lay their eggs. This spray is usually applied in combination with a fungicide for the control of apple scab. The addition of molasses or other sweetening is unnecessary and reduces the sticking qualities of the spray.

Recent experiments indicate that calcium arsenate may be substituted for lead arsenate (page 91).

The first spray should be applied shortly after the flies begin to emerge. In the Hudson Valley this is usually the last week in June. The flies tend to appear a few days later in western New York and in the Champlain area than in the Hudson Valley. For the more nearly accurate timing of apple-maggot sprays, large trap cages are used by the farm-bureau spray-information service in certain counties to determine the daily emergence of flies from the ground. For varieties ripening after McIntosh, lead arsenate may be used in the first spray; but for McIntosh and earlier varieties, it is preferable to use calcium arsenate to reduce spray residue. A second spray should be applied in about two weeks, using calcium arsenate on all varieties unless it is planned to wash the fruit. These two sprays with a

fungicide afford protection not only against the apple maggot but against the codling moth and apple scab as well.

Nicotine is not effective against apple maggot.

It will often simplify the spraying program to cut down, or top-work, the occasional sweet-apple trees in commercial orchards, since these are seldom profitable and often constitute a real menace because of the apple maggots that they harbor. Neglected trees in hedgerows, in adjoining fields, and about farm buildings also are such a menace, and should likewise be cut down.

It is important that all trees in infested orchards be thoroughly sprayed. This applies not only to apple trees in their off-bearing year, but also to other fruits interplanted with apples. Experience has shown that failures to control the apple maggot are especially likely to result if spraying is confined to trees with fruit. Neglected orchards, and scattered trees near and adjoining commercial plantings, also should receive the maggot sprays.

Arsenical dusts are effective against the flies, but additional applications will be required if rains occur. Growers estimate that usually three dusts are necessary to give protection equal to that from two sprays.

ROSE LEAF-BEETLE

(*Nodonota puncticollis* Say)

In certain orchards in the Hudson Valley the rose leaf-beetle has caused important losses during recent years. The beetle is about $\frac{1}{5}$ inch in length, bronzy green to bluish in color, and rather strongly convex above. The beetles are to be found not only on apple and pear trees but

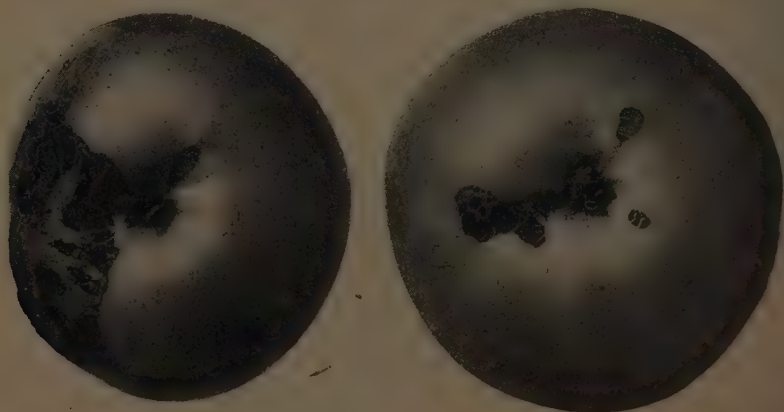


FIGURE 12. APPLES INJURED BY THE ROSE LEAF-BEETLE

also on wild blackberries and cornel growing in fence rows about the orchard. They feed on the foliage of these plants and on the leaves and fruit of apples and pears. In feeding they eat out shallow cavities on the surface of the apple. Badly injured fruits drop prematurely but those less severely injured may reach maturity; they are, however, badly scarred and of little commercial value. (Figure 12.)

Control

The rose leaf-beetle can be controlled by spraying with lead arsenate, 3 pounds in 100 gallons of spray material, if the spray is applied as soon as the beetles make their appearance on the trees. If the first spray is deferred until the beetles have begun to feed on the fruit, the results are likely to be disappointing. The first spray usually coincides with the special curculio spray, about ten days after the calyx application. The second application is usually combined with the first codling-moth cover spray.

Since the beetles may alternate while feeding from blackberries and cornel to apples, it is suggested that these plants in and bordering the orchard be sprayed also where this pest is a serious problem.

ROSE CHAFER

(*Macrodactylus subspinosus* Fabricius)

The rose chafer is an ungainly long-legged grayish brown beetle about $\frac{1}{2}$ inch in length. The beetles invade the orchards, often in swarms, about the middle of June. They feed on the tender foliage and attack the young fruits. They eat out holes in the apples causing them to fall prematurely or to be so badly scarred as to be worthless.

Fortunately, the rose chafer is restricted as a pest to sandy regions. The larva of the chafer is a grub that feeds on the roots of grasses in sandy soil. The female beetle will not enter the heavier soils for egg laying nor do the grubs thrive under such conditions.

Control

Serious injury by the rose chafer can be prevented by spraying with 3 pounds of lead arsenate in 100 gallons of the spray mixture. It is important to make the application just as soon as the first beetles appear on the trees.

WHITE APPLE LEAF-HOPPER

(*Typhlocyba pomaria* McAtee)

The white leaf-hopper is the most troublesome species of leaf-hopper attacking bearing apple trees in the Hudson Valley. The insect passes the

winter in the egg stage on apple. The overwintering eggs are deposited in the bark, and hatch during the latter part of May. There are two generations, the second reaching maturity in September. The white leaf-hopper feeds on the underside of the leaves, causing a whitish stippling on the upper surface. In severe cases the spots coalesce, the leaves become blanched, and little green coloring matter is left. In addition to injuring the leaves, the second brood of hoppers may speckle the fruit with excrement, rendering it unsightly and lowering its market value. This is true especially of Rhode Island Greening and other light-colored varieties.

Control

Leaf-hopper nymphs are readily killed by spraying with nicotine sulfate, either with soap or in combination with the regular sprays. Care must be taken to hit the underside of the leaves, where the insects are to be found. In the Hudson Valley hatching is not complete until about ten days after the calyx application. It is usually not advisable to spray for the first brood except where the infestation is excessive. If it is considered profitable to spray for this brood, the application should be made after the nymphs have hatched, or during the first week in June. In this application the nymphs may be killed with $\frac{3}{4}$ pint of nicotine sulfate in 100 gallons of the spray mixture. The nymphs of the second brood usually appear in August, after the completion of the regular spraying schedule. If the nymphs are present in alarming numbers, they may be killed by spraying with nicotine sulfate, $\frac{1}{2}$ pint in 100 gallons of water in which 1 pound of soap flakes or 3 pounds of fish-oil soap has been dissolved. If the weather is cool it is better to use $\frac{3}{4}$ pint of nicotine. This application should be made before the nymphs reach maturity.

SOOTY BLOTCH AND FLY-SPECK

(*Gloeodes pomigena* (Schweinitz) Colby)

(*Leptothyrium pomi* (Montagne & Fries) Saccardo)

Sooty blotch and fly-speck, although caused by two different fungi, are here considered under one heading because they frequently occur together and are controlled by identical measures.

Sooty blotch (figure 13) appears on the fruit as sooty brown or black spots or blotches, which may measure only $\frac{1}{4}$ inch in diameter or which may coalesce and cover the entire apple. Dealers often call this condition "cloud" or "cloudy fruit." The spots show a radiating structure composed of a thin felt of the dark, interwoven threads of the fungus.

Fly-speck, as the name indicates, consists of groups of black, shiny dots on the apple, closely resembling those made by flies.

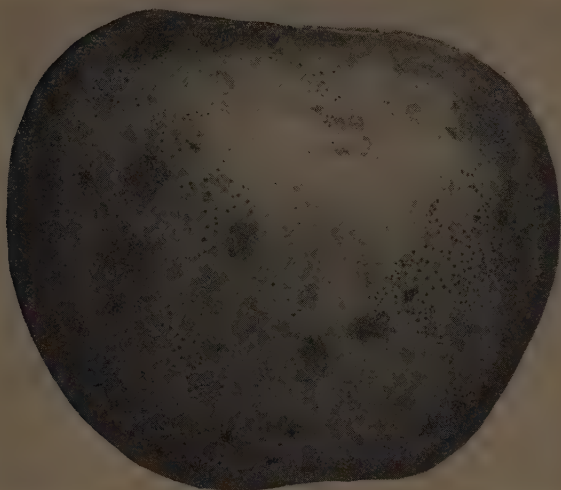


FIGURE 13. SOOTY BLOTCH AND FLY-SPECK ON APPLE FRUIT

Sooty blotch and fly-speck are diseases of considerable economic importance in New York. Although the disfiguration caused by the fungi is superficial, it often reduces the grade and the market value of the fruit.

Control

These diseases usually are easily controlled where the customary summer applications are made for the control of codling moth and apple scab (page 9).

BROOKS FRUIT-SPOT

(Caused by the fungus *Mycosphaerella pomi* Passerini)

Brooks fruit-spot, known also as *Phoma fruit-spot*, is a disease of apples frequently found in the Hudson Valley, where it has caused considerable loss in some years. It has occasionally been found in western New York, but not to a serious extent.

Jonathan, Baldwin, Tolman Sweet, Grimes Golden, Rome Beauty, and Stayman Winesap are the varieties most commonly affected. In New York the disease has been found also on Rhode Island Greening, Bell-flower, Ben Davis, Delicious, and Mann.

The spots, which seldom exceed $\frac{3}{16}$ inch in diameter, are red or black when they occur on red areas of the fruit, and dark green or green on

yellow surfaces. The center is usually flecked with black. The spots are irregular in outline, slightly sunken, and usually more abundant near the calyx end of the apple. They are often very inconspicuous at picking time, but if the fruit is not placed at once in cold storage they usually become more sunken and considerably larger, with a corky layer under the skin.

The Brooks fruit-spot, which is a fungous disease controlled by spraying, is often confused with stippen. Stippen is a fruit spot on apples caused by sudden changes in the water supply of the tree, and consequently cannot be controlled by spraying. The sunken spots caused by stippen are very similar to those caused by the *Mycosphaerella* fungus in the early stages. However, at picking time the Brooks spots show black specks which are not present in stippen. At this time the spots caused by stippen usually turn brown, are more sunken, and have a distinct dry spongy area underneath which is not present under a Brooks spot. An apple affected with stippen will usually be found to contain brown streaks or spots of dry, spongy flesh throughout its pulp; such streaks or spots are not present with *Mycosphaerella* fruit-spot.

Control

Under New York conditions, where the regular summer sprays of lime-sulfur and lead arsenate are applied this disease is adequately controlled.

TWO LATE-SUMMER CATERPILLARS

Yellow-Necked Apple Caterpillar (*Datana ministra* Drury)

Red-Humped Apple Caterpillar (*Schizura concinna* Smith & Abbott)

The yellow-necked and the red-humped apple caterpillar, each well described by its common name, often attract attention in August. They feed in colonies, and strip the leaves from occasional branches. They are most abundant on young trees that have not been sprayed. The injury caused by these caterpillars is not so serious as appearances would indicate. They work late in the season, after the foliage has reached maturity, but trees badly defoliated are more subject to winter injury.

Control

On bearing trees that are regularly sprayed, these caterpillars are of little importance. On young trees they may be jarred to the ground and crushed, or the trees may be sprayed with a poison while the caterpillars are small.

PEAR

A practical spray schedule for pears in New York must be built around the control measures required for pear psylla, since this pest is by far the

most serious of any to the pear crop. Within recent years the fruit tree leaf-roller, green fruit worms, sinuate pear borer, and quince curculio have caused damage in many orchards. The following spray schedule includes control measures for all of these pests. Fortunately, it will not be necessary for all growers to apply all of the sprays indicated. The grower will have to select from the schedule those sprays needed for protection in his particular orchard.

SPRAY OUTLINE FOR PEARS

Two methods of control are used against psylla. One is based on a dormant application of lubricating-oil emulsion or miscible oil, the other on a cluster-bud application of lime-sulfur 1-8.

When an oil spray is used for psylla

Dormant spray (Early in the spring, when the flies appear on the twigs and are ready to lay eggs)

Lubricating-oil emulsion or miscible oil diluted to contain 3 per cent of oil.

This dormant spray is effective against psylla and scale.

Pre-blossom spray (When the blossom buds begin to separate in the cluster)

Lead arsenate	3 pounds
Hydrated lime	3 pounds
Spreader	½ pound
Water to make.....	100 gallons

If scab is a problem, add either

Lime sulfur	2 gallons
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or use

2-20-100 bordeaux mixture

The arsenate of lead should be included in orchards where leaf roller or green fruit worm is a problem. If leaf roller is a serious problem, the lead arsenate and lime are increased to 6 pounds each.

If the midge is a problem, this spray should contain 1 pint of nicotine sulfate in 100 gallons and should be timed especially for the midge.

Calyx spray (When the last of the petals are falling)

Copper sulfate	2 pounds
Lead arsenate	3 pounds
Hydrated lime	20 pounds
Water to make.....	100 gallons

In most orchards it will not be necessary to apply both the calyx and first nymph sprays. The choice will depend on the relative importance of

the insects concerned. If green fruit worm and leaf roller are abundant, the application should be made at the calyx stage. For leaf roller, 6 pounds of lead arsenate is advised. If, on the other hand, these insects are unimportant and psylla is not under control, the calyx spray should be omitted and the first nymph spray should be applied. If the false tarnished plant bug is present, 1 pint of nicotine sulfate should be added to the above formula in the calyx spray.

First nymph spray (About ten days after the petals have fallen)

Copper sulfate	2 pounds
Hydrated lime	20 pounds
Lead arsenate	3 pounds
Nicotine sulfate	1 pint
Water to make.....	100 gallons

This spray is timed especially for the pear psylla and should be delayed until most of the eggs have hatched. It also furnishes protection from codling moth.

Special spray for rose leaf beetle, quince curculio, and sinuate pear borer
(About June 10)

Lead arsenate	3 pounds
Hydrated lime	3 pounds
Spreader	$\frac{1}{2}$ pound
Water to make.....	100 gallons

If sinuate pear borer is a problem, the lead arsenate should be increased to 5 pounds.

Summer sprays (When psylla becomes threatening)

Early summer spray (In July when most of the second-brood eggs are hatched)

At this time the grower may use any one of three mixtures:

(1) Copper sulfate	2 pounds
Hydrated lime	20 pounds
Nicotine sulfate	1 pint
Water to make.....	100 gallons
(2) Summer-oil emulsion	2 gallons
Nicotine sulfate	$\frac{1}{2}$ pint
Water to make.....	100 gallons
(3) Nicotine sulfate	1 pint
Soap chips	1 pound

OR

Potash fish oil soap.....	3-5 pounds
Water to make.....	100 gallons

Late summer spray (Early in August if psylla becomes abundant and threatens to smut the fruit.

Nicotine sulfate and soap as indicated above should be used in this application.

When lime-sulfur is used for psylla

Cluster-bud spray (When the blossom buds have separated in the cluster, for Bartlett; when they begin to separate for Kieffer)

Lime-sulfur	11 gallons
Water to make.....	100 gallons

If the midge is a problem, this spray should contain 1 pint of nicotine sulfate in 100 gallons and should be timed especially for the midge.

The cluster-bud spray is directed against the eggs of psylla. It will also prevent early infections of pear scab. For effective results, it is absolutely essential to cover the underside of the branches from below.

For the calyx and later sprays, follow the directions given under the oil schedule.

PEAR PSYLLA

(*Psyllia pyricola* Förster)

The pear psylla is by far the most important insect pest of the pear in New York. It is most serious in the commercial pear-growing districts, and in some of these it has been so destructive and so difficult to control as to render commercial pear-growing largely unprofitable. The insect is not equally serious in all orchards, but is more of a problem in large plantings and in sheltered orchards. In seasons when the psylla is especially abundant, it is a serious problem in practically all orchards. Where it is not controlled, it often causes early defoliation and loss of crop, and so weakens the trees that they suffer winterkilling and a reduction in the succeeding year's crop,

The adults pass the winter under flakes of bark on pear and other near-by trees, and in trash and other shelter along adjacent fences and hedgerows. The psylla adults are commonly known as *flies* and have been aptly likened to tiny cicadas. They are about $\frac{1}{10}$ inch long, are dark reddish brown, and have relatively large, transparent wings which slope roof-like over the abdomen. Their legs are adapted for jumping.

The flies emerge from their hibernating quarters during sunny days in early spring when the temperature is above 50° F. If the weather continues warm they crawl out on the smaller branches and spurs of the trees, and in a few days the females begin to lay eggs. Later, intermittent cold spells may cause the adults to return to shelter and thus interrupt and prolong the egg-laying period. In some seasons most of the eggs have

been deposited by the time the blossom buds separate in the cluster, but in cool seasons egg-laying may continue through the blossoming period. The small, elongate eggs are laid end to end in crevices around the buds, mainly on the underside of the smaller branches and fruit spurs and later on the lower surface of the opening leaves along the midrib. Although they are white when laid, the eggs soon change to lemon yellow, deepening to orange as they near hatching. The eggs hatch in nine days to four weeks, depending on the temperature. The majority of the eggs hatch during the blossoming period, and in normal seasons hatching is practically completed about a week after the petals have fallen although in some years the last eggs are not hatched until two weeks after petal-fall.

The newly hatched nymphs are so small as to be hardly visible to the unaided eye. They migrate to the opening buds and settle at the bases of the leaf petioles and the fruit stems, where they pierce the tissue with their bristle-like mouth-parts and suck out the plant juices. They grow rapidly, passing through five immature stages and becoming winged adults at the fifth molt. During the first three stages, the nymphs are yellow and are covered by a sticky excretion called *honeydew*. The fourth and fifth stages are known as *hardshells*, and during these stages relatively little honeydew is secreted. In the fourth stage the body is marked with blue shading to brown, and in the fifth with dark brown. The summer flies are smaller, and lighter in color, than the overwintering adults.

The completion of the life cycle requires about a month, and there are three or four generations in a season. Each female lays about 500 eggs. Under favorable conditions the insect may increase to enormous numbers, even from a few overwintered flies. The summer broods overlap to a considerable extent, so that after the first generation all stages may be present at the same time.

The feeding of the nymphs dwarfs the leaves, produces brown, dead areas, and in severe instances causes the foliage to drop prematurely. Foliage injury results in undersized, poor-quality fruit, prevents normal fruit-bud formation, and weakens the tree. Early defoliation is often followed by winterkilling of branches and by a reduction in the crop for several succeeding years. The fruit is often badly stained and reduced in market value by a sooty fungus which grows in the sticky coating of honeydew.

Control

The pear psylla is a very difficult pest to control and no single treatment can be relied upon when it is abundant. Control measures are divided into two groups: (1) a 3-per-cent lubricating-oil emulsion applied as the buds are swelling, and (2) lime-sulfur 1-8 applied in the cluster-bud stage. If

either of these treatments is used, the other is unnecessary. Most growers are now using the oil spray, but under certain conditions the lime-sulfur treatment is preferable. In either case applications after the bloom may be necessary in years of heavy infestations.

Control with oil

Lubricating-oil emulsion or miscible oil is used, diluted so as to contain 3 per cent of oil when applied. The lubricating-oil emulsion spray can be prepared from commercial stock emulsion, or from oils emulsified in a spray tank. The spray should be applied on sunny days in March or early April when the flies appear in numbers on the branches but before many eggs are laid. At this time the buds are swollen but the tips of the leaves are not yet exposed.

Although the killing of flies is important, much of the effectiveness of the spray results from the coating of oil residue left on the trees. This repels the flies so that fewer eggs are deposited, and also kills many of the newly hatched nymphs as they attempt to crawl over it to the leaves.

A single application seldom injures the trees unless they are exceedingly weak. However, if repeated applications are made annually, oil injury may result on those with moderate to low vitality. This is most noticeable on trees weakened by winter injury or by previous attacks of the pear psylla. On moderately weak trees the oil treatment should not be continued for more than one or two years in succession. If the trees are vigorous, the orchard should be carefully watched, and, when oil injury is observed, the treatment should be discontinued. If the trees are extremely weak it is not safe to use oil sprays.

Control with lime-sulfur

To be most effective, the cluster-bud application with lime-sulfur 1-8 (11 gallons to 100) should be applied at as late a date as possible before blossoming. It is most effective in years when the flies lay most of their eggs before it is too late to apply the lime-sulfur spray.

The use of lime-sulfur 1-8 at the cluster-bud stage was formerly widely practiced. It has now been largely supplanted by the dormant oil treatment, since in cool seasons the lime-sulfur spray is somewhat less effective because many eggs will have been laid at so late a date that they will not have reached the susceptible stage by the time the lime-sulfur spray is applied. Furthermore, a considerable number of eggs may be deposited after the latest date at which the spray can be safely applied. But even under these conditions the cluster-bud spray is worth while whenever psylla is a serious problem, since it prevents considerable injury that would otherwise occur before the first nymph spray. It also makes the nymph sprays more completely effective by killing early-laid eggs and

early-hatched nymphs. As a result, most of the psyllas left on the tree are in the more susceptible early-nymph stages when the nymph spray is applied. To be most effective, the cluster-bud spray should be applied at as late a date as possible before blossoming.

Slight foliage injury is likely to result from the use of lime-sulfur 1-8 at the cluster-bud stage, but there is little danger of injuring the flower buds. The Bartlett variety has but little leaf area exposed just before blossoming, while in the Kieffer variety the leaves are much more expanded. To avoid danger of burning, it is well to spray Kieffer just as the buds begin to separate in the cluster. Seckel and Clapp can be safely treated a little later; Bartlett, Bosc, and other varieties should be sprayed when the buds are fully separated, the operation being completed just before blossoming. If overwintered flies are still numerous and still laying eggs, it may sometimes pay to add 1 pint of nicotine to each 100 gallons of the spray mixture.

Only a very thorough application is worth while, and careless spraying is certain to result in failure. A majority of the psylla eggs are deposited on the underside of the spurs and the smaller branches and on the water sprouts, so that the most effective method is spraying from the ground.

First nymph spray

If psylla has not been controlled by earlier applications, sprays directed against the nymphs may be necessary.

The formula for this application is given on page 52.

A driving spray with considerable pressure should be employed, so that the sprays will be forced between the bases of the leaf petioles and the fruit stems, where many of the nymphs are sheltered. Thorough spraying is essential.

Early summer spray

In seasons of abundance, or where the early sprays are omitted or carelessly applied, a later application may be necessary. When considerable amounts of honeydew indicate that psylla is abundant, a spray should be applied in July at the time when most of the second-brood eggs have hatched. At this time the grower may use one of three mixtures suggested on page 52.

Late summer spray

Sometimes psylla becomes abundant in early August, shortly before fruit picking, and threatens to smut the crop. When this occurs, the soap and nicotine spray mentioned on page 52 should be used to prevent residue on the fruit.

FRUIT-TREE LEAF ROLLER

(*Cacoecia argyrospila* Walker)

The fruit-tree leaf roller, together with the green fruit worm, causes the so-called knarly or goose-knecked pears. Since, on pears, it is not safe to use an oil spray that is strong enough to destroy the eggs of the leaf-roller, reliance must be placed on the use of lead arsenate in the pre-blossom and calyx applications to kill the young larvae. In severe infestations lead arsenate should be used at the rate of 6 pounds in 100 gallons of the spray mixture. (For further discussion of this pest, see page 27.)

FALSE TARNISHED PLANT-BUG

(*Lygus communis* Knight)

The false tarnished plant-bug is present in occasional pear orchards throughout the State, and may cause a large proportion of the fruit to become knotty and deformed.

The insect passes the winter in the egg stage in the bark of the smaller branches of the trees. The eggs hatch during the blossoming period, and the young nymphs, after feeding for a time on the expanding leaves, attack the fruit as soon as it has set. In feeding, the nymphs puncture the fruit with the bristles of the beak and suck out the plant juices. The tissue around the puncture becomes hard and gritty. Growth at that point is retarded, and a deep pit or dimple develops. Badly punctured fruits are not only deformed but also dwarfed. The nymphs are at first pale in color, but they become greenish after the first molt. They pass through five immature stages and become mature about the middle of June. The adult is about $\frac{1}{4}$ inch in length and is light brown. There is only one brood a year. Most of the injury is caused during June, while the fruits are still small.

Control

Where false tarnished plant-bug is the only problem, the nymphs can be killed by a thorough application, made soon after the petals have fallen, of nicotine sulfate, 1 pint in 100 gallons of water in which 1 pound of soap flakes or 3 to 5 pounds of potash fish oil soap has been dissolved. The calyx spray, containing nicotine sulfate, copper sulfate, and hydrated lime (page 51), is effective in the control of this pest, and, if this is used, no extra application is necessary.

PEAR SCAB

(Caused by the fungus *Venturia pyrina* Aderhold)

Pear scab is very similar in appearance to apple scab and is caused by a closely related fungus, but the two diseases are distinct. The pear-scab

fungus does not attack apple, nor does the apple-scab fungus attack pear.

The pear-scab fungus, like the apple-scab fungus, overwinters as partly developed fruiting bodies (perithecia) in the old fallen scabby leaves. Unlike apple scab under New York conditions, it overwinters also to a considerable extent in affected twigs. The young twigs are rather commonly affected but the spots are very inconspicuous and easily overlooked. Limited observations in western New York indicate that in that area a considerable proportion of the pear-scab fungus fails to survive the winter in the twigs so that the overwintering stage in the leaves is much more important. Pear scab has been less serious in the Hudson Valley, and the importance of the two methods of passing the winter in that area is not known.

The spring spores (ascospores) of the pear-scab fungus mature in the perithecia somewhat later than do those of the apple-scab fungus. When the ascospores are ripe, they are shot out of the dead leaves during wet periods and infections take place as described for the scab on apple. Summer spores also are produced on the affected twigs and are washed to leaves and fruit, creating an important method of spread which very rarely exists with apple scab in New York.

In general pear scab is not serious except on such varieties as Flemish Beauty, Winter Nelis, and Easter Beurre.

Control

In most commercial pear orchards, the seasonal spray schedule followed for pear psylla and other troubles is sufficient for scab control. An application of a fungicide at the cluster-bud stage is advisable.

BLISTER-MITE

(*Eriophyes pyri* Pagenstecher)

The leaves of pear and of apple are often disfigured by small, reddish or greenish yellow blisters, caused by blister-mites. These later turn brown. Badly infested leaves turn somewhat yellow and fall prematurely. The adult blister-mites pass the winter in the buds, beneath the second and third scales. With the bursting of the buds in the spring, the mites migrate to the leaves, burrow through the upper surface, and lay eggs. The young mites feed on the tender tissue inside the leaf, and cause the formation of swellings or blisters. When mature, the mites escape from the blisters through minute holes in the underside of the leaf. They then migrate to fresh leaves and start new blisters. Breeding is continued throughout the summer.

Control

This pest is seldom serious enough to warrant special control measures. It is readily controlled by lime-sulfur 1-15, or by miscible- or lubricating-

oil sprays applied in the spring before the buds break. The oil sprays used for psylla and thrips will control this pest also.

CODLING MOTH

(*Carpocapsa pomonella* Linnaeus)

(See also under *Apple*, page 33)

The codling moth is an important pest of the pear and sometimes it causes serious injury where control measures are not used. Because of the tougher character of the pear skin, a larger proportion of the larvae are thought to enter through the calyx cup than in the case of the apple.

Control

The first spray for the control of codling moth is applied shortly after the petals have fallen, and contains 3 pounds of lead arsenate for each 100 gallons of the spray mixture. The arsenical is usually added to the first nymph spray (page 52). If psylla is not a pest in the orchard, the arsenical should be used with a bordeaux mixture containing 2 pounds of copper sulfate, 20 pounds of hydrated lime, and water to make 100 gallons. If additional sprays are applied, it may be necessary to wash the fruit to remove residue. Because of the difficulty experienced in washing pears, residue should be avoided as far as possible on this fruit.

QUINCE CURCULIO

(*Conotrachelus crataegi* Walsh)

In a few scattered orchards throughout the State, the quince curculio sometimes causes considerable injury to pears. Fruit injured by the feeding and egg-laying punctures of the curculio frequently becomes knotty and deformed, but the presence of feeding punctures, even without deformation, will cause the pears to drop just before picking time. In some orchards, from 70 to 80 per cent of the crop has been lost because of attack by this pest.

Control

Infested orchards should be sprayed with 3 pounds of lead arsenate, 3 pounds of hydrated lime, and $\frac{1}{2}$ pound of spreader in 100 gallons of spray mixture, as soon as the beetles emerge from the ground. The time of emergence may vary considerably from year to year, but in the Hudson Valley it is usually during the first week in June. The time of appearance of the beetles can be determined by jarring trees at intervals, beginning in late May. An easy method of determining the time of application is to watch for the first feeding punctures on the fruit. These usually will be found first near the stem end of the pears. This application can usually

be combined with the one timed for the control of the rose leaf beetle and the sinuate pear borer. During some seasons a second application is advisable. Two applications are usually sufficient.

PEAR MIDGE

(*Contarinia pyrivora* Riley)

The pear midge is a major pest of the pear in the Hudson Valley. In badly infested orchards the entire crop of certain varieties may be destroyed. All varieties are attacked, but Lawrence is the most seriously injured and Kieffer the least.

The adult pear midge is a small, mosquito-like fly, distinguishable from other midges by its more delicate build and its unusually long legs. The midges usually emerge from the ground at about the time the blossom buds of Clapp Favorite are separating in the cluster. The female soon moves to the buds, and, by means of her long, flexible ovipositor, lays her eggs inside the unopened blossoms. This is done as soon as the petals have developed sufficiently to permit the insertion of the ovipositor. From 20 to 30 eggs may be deposited in a single bud. The eggs hatch in about a week, and the tiny larvae work their way into the ovary and hollow out a large cavity in the center of the developing fruit.

Infested fruits are at first larger than normal, but later they become stunted and deformed and in a few weeks drop to the ground. When the larvae are full-grown, they either drop to the ground through cracks which develop in the side of the fruit or drop with the fruit. They usually pupate soon after entering the soil, and remain in this state until the following spring.

Control

The pear midge can be controlled by a contact spray to kill the adult midges before they can lay their eggs. The spray should be applied after the flies are out and the sepals have separated on the most advanced buds. The application must be completed without delay, since the time for effective spraying is often only a day or two. Owing to the difficulty of proper timing of the spray, growers should avail themselves of the farm-bureau spray information service. The entire tree, including the trunk, should be thoroughly covered, and all the trees in the orchard should be sprayed. Nicotine sulfate, 1 pint in 100 gallons of the spray mixture, is added to a solution of lime-sulfur 1-8 if psylla is to be combated at the same time, or to lime-sulfur 1-50 or bordeaux mixture 2-20-100 if for pear midge and pear scab. Two gallons of summer-oil emulsion, 1 pint of nicotine sulfate in 100 gallons of water may be used at this time if a fungicide is not needed. If psylla is the important problem the application should be timed for the control of this insect rather than for the midge.

PEAR THRIPS

(*Taeniothrips inconsequens* Uzel)

Although pear thrips is present throughout the State, it has been destructive chiefly in parts of the Hudson Valley. During some seasons the insect causes severe blasting of blossoms and leaf buds and a heavy reduction of the crop in a considerable number of orchards. The thrips attacks plum, cherry, and apple, also, but the injury to these fruits is negligible.

The adult thrips are slender, brownish insects about $\frac{1}{20}$ inch length, with long, narrow wings fringed with long hairs. In the spring they emerge from the soil and appear on the trees, usually just as the buds are bursting. They soon work their way into the opening buds and attack the tender flower and leaf parts. If the thrips are numerous, and especially if cool weather retards the further opening of the buds, many blossom clusters are shriveled or blasted and later fall off, while others are stunted and deformed and drop their fruit prematurely. The thrips lay their eggs mainly in the stems of the blossoms and leaves, beginning as soon as the buds open. The young thrips are small, white creatures, with red eyes, and they hatch in numbers during the blossoming period. They feed in the calyx cups of the blossoms and on the foliage, thus adding to the injury caused by the adults. They become full-grown in two or three weeks, fall to the ground, and enter the soil, sometimes to a considerable depth. In the fall they change to pupae. The pupae pass the winter in tiny cells in the ground.

Control

The only known method of control for pear thrips consists of spraying with 1 pint of nicotine sulfate in 100 gallons of either a 3-per-cent lubricating-oil emulsion or a miscible oil diluted at manufacturers' recommendations. This spray will kill the adult thrips while they are clustered on the opening buds. The time for effective spraying is short, and the grower should watch his orchard carefully and should spray as soon as thrips are found to be numerous on the buds and the branches. If thrips continue to appear, a second application a few days later may be desirable. In seasons when large numbers of thrips swarm on the buds before these are expanded enough for the insects to enter, the thrips can be successfully controlled. When, however, they emerge a few at a time and the buds are open enough for them to enter, satisfactory control is impossible. This application controls pear psylla as well as pear thrips.

A good spray containing nicotine, if thoroughly applied shortly after the petals have fallen, will kill a large proportion of the young larvae,

or "white thrips," and will greatly reduce the infestation for the following year. This application corresponds to the regular first psylla-nymph spray and contains the same materials. (See page 52.)

SINUATE PEAR BORER
(*Agrilus sinuatus* Olivier)

The sinuate pear borer has been present in the Hudson Valley for nearly forty years. In 1933 it attracted renewed attention because of a marked increase in abundance and in the damage caused to trees weakened by winter injury. It now appears to be the most serious insect enemy of the pear in this region. In addition to pear it breeds principally in quince, hawthorn, and mountain ash.

The adult of the sinuate pear borer is a slender, shining, coppery red or purplish beetle about $\frac{1}{3}$ inch in length. The beetle passes the winter in a cell in the sapwood of the tree. The beetles begin to appear in late May or early June and continue to emerge till about July 1 or a little later; the peak of emergence is about the middle of June. The beetles may be found on the bark and leaves on the sunny side of the tree. They feed on the leaves for a period of about 10 days before beginning to lay eggs. The eggs are deposited on the trunk or branches and are usually placed in cracks or depressions in the bark. The eggs hatch in June and July and the slender whitish grubs eat out narrow winding burrows in the sapwood. The partly grown larva either matures in the fall or rests in its burrow during the first winter and the next spring continues its destructive work. The burrows are now much larger and more winding; they frequently intersect, cutting off the supply of sap, and the branch or tree dies. The course of the burrows is now indicated exteriorly by the discolored and abnormal bark above them. In smooth-barked trees these winding trails become very conspicuous. In September the larva, which is now about $1\frac{1}{2}$ inches in length, burrows into the solid wood and there at the depth of about $\frac{1}{4}$ inch constructs a pupal chamber which it connects with the bark by an exit hole. It then plugs both ends of the chamber with sawdust, becomes shorter and thicker, and the following April transforms to a pupa.

Control

Spraying with a poison to kill the beetles before they lay their eggs is a promising and practical method of control. Lead arsenate is used at the rate of 5 pounds in 100 gallons of spray mixture. The first application should be made about June 10, followed by a second application about two weeks later. In orchards where there is danger of an invasion of beetles from surrounding orchards, a third application, about ten days after the second, may sometimes be warranted. Attempts to control the

borer by spraying should always be supplemented by digging out the borers in May wherever they can be located. On young or smooth-barked trees this is an easy thing to do, but is much more difficult on old rough-barked trees. It is also important to destroy all thorn-apple, hawthorn, and mountain-ash trees growing near the orchard and thus prevent an increase in the number of beetles from this source. All worthless pear and quince trees also should be eliminated.

PEAR LEAF-BLIGHT

(Caused by the fungus *Fabraea maculata* (Leville) Atkinson)

Pear leaf-blight is caused by the same fungus that produces leaf-blight on quince.

Leaf-blight occurs commonly on pears in practically all nursery districts. It is said to be more abundant in the Hudson Valley pear orchards than elsewhere in New York. The greatest damage is on pear seedlings in the nurseries, but occasionally severe injury is done to leaves and fruit of trees in bearing orchards.

The leaf-blight fungus causes a spotting of pear leaves very similar to that produced on quince by the same fungus. The spots on the leaves differ from the spots of the *Mycosphaerella* leaf-spot by being smaller, more nearly circular, and darker colored. There is one raised black dot in the center of the leaf-blight spot, in contrast to the numerous small black bodies in the *Mycosphaerella* leaf-spot. The spots on the fruit are at first red, but later they become dark-colored. The skin is roughened, and cracking of the fruit may follow.

Control

The disease may be controlled with lime-sulfur or bordeaux mixture. Unfortunately, lime-sulfur, at any dilution, is extremely unsafe on pear trees after the blossoming period. Bordeaux mixture 6-16-100 will control the disease, but is likely to cause russetting of the fruit. Experiments have not been made to determine the control obtained by the weak bordeaux spray recommended for pears in the spray schedule containing but 2 pounds of copper sulfate in 100 gallons of the spray mixture (page 52). Unless the leaf-blight has been serious in the orchard, it would seem safer to use this weak copper-lime spray on bearing trees. On seedlings in nurseries the stronger bordeaux mixture may safely be used. Sulfur dust, copper-lime dust, and dry-mix sulfur lime spray have not been tested, but from the results obtained with the disease on quinces it would seem probable that the sulfur dust and the dry-mix sulfur-lime spray might give commercial control, while the copper-lime dust cannot be relied upon.

MYCOSPHAERELLA LEAF-SPOT

(Caused by the fungus *Mycosphaerella sentina* (Fries) Schroeder)

Mycosphaerella leaf-spot is usually called *Septoria leaf-spot* or simply *pear leaf-spot*.

When heavy leaf infections occur, defoliation may take place by August or earlier. This results in checking the ripening of buds and shoots, and causes the tree to be susceptible to winter injury. The leaf-spot is recognized by the dark, angular spots with light gray centers, which contain the very dark, pin-point-like fruiting bodies of the fungus. The fungus overwinters in the fallen leaves, from which its spores are shot in the spring during rain periods.

Control

This disease is of little importance in well-sprayed pear orchards. Frequent inquiries regarding it are received from owners of unsprayed pear trees.

CHERRY

Under New York conditions, cherries are sprayed principally for the control of leaf-spot, fruit-flies, and brown rot. In some locations the plum curculio also may require attention. The black cherry aphid is confined as a pest mostly to sweet cherries.

SPRAY OUTLINE FOR CHERRIES

Dormant spray (Before the buds open)

Tar-distillate emulsion containing 1.8 per cent of tar oil in the diluted mixture is used. (See table page 96.)

This spray is applied for the control of the black cherry aphid and usually is not necessary on sour cherries.

Green-tip spray (When the bud scales separate and expose the green blossom buds)

Lime-sulfur	2 gallons
Nicotine sulfate	1 pint
(Omit on sour cherries and also on sweet cherries if tar-distillate emulsion has been used.)	
Water to make	100 gallons

This spray is applied for the control of brown rot, blossom blight, and black cherry aphid. It is important in most seasons on English Morello for brown rot and usually is not necessary on other varieties of sour cherries. It is needed on all varieties of sweet cherries.

If dust is used, dusting sulfur is indicated.

Petal-fall spray (When the last of the petals are falling)

Lime-sulfur	2 gallons
Hydrated lime	2½ pounds
Lead arsenate	2½ pounds
Spreader	½ pound
Water to make	100 gallons

This spray is effective against leaf spot, brown rot, and curculio.

If a dusting schedule is followed, 90-10 sulfur-lead-arsenate is indicated. If curculio is abundant, an 80-20 mixture of the same materials may be used.

Shuck spray (When the shucks are falling from the fruits that are going to set)

Lime-sulfur	2 gallons
Hydrated lime	2½ pounds
Lead arsenate	2½ pounds
Spreader	½ pound
Water to make.....	100 gallons

This spray is effective against curculio, leaf spot, and brown rot.

If dust is used, an 80-20 sulfur-lead-arsenate mixture is indicated.

In order to reduce the danger of excess residue, it is suggested that the lead arsenate in this spray be increased to 4 or 5 pounds and that 1 pound of calcium arsenate be used in the first maggot spray, and ½ pound in the second maggot spray, the purpose being to have the poison present early and thus to eliminate a heavy application later.

Where this program is to be followed, it is suggested that the spray be applied at the pre-shuck stage; that is, after the petals fall but before the shucks are off. It has been found that if this program is followed and the application is delayed until after the shucks are all off, the danger of excessive residues is greatly increased. In addition, if this schedule is followed, regardless of the timing, there will be no definite assurance that the crop will be free of excessive spray residue at harvest time.

Morello cherries are susceptible to stem injury where arsenicals are used; it will not be advisable to use increased dosages of lead arsenate on this variety, but from 1 to 2 pounds of arsenical is advised.

Later sprays

These later sprays are for cherry fruit flies, leaf spot, and brown rot.

At this point it will be necessary to modify the spray schedule depending upon the use to which the cherries are to be put: (1) canning cherries that are to be washed or (2) cherries that are to be consumed as fresh fruit.

For canning cherries that are to be washed

First fruit-fly spray (A week after the fruit flies have first appeared, or about the time Early Richmonds first show a tinge of color)

Lime-sulfur	2 gallons
Hydrated lime	2½ pounds
*Lead arsenate	2½ pounds
Spreader	½ pound
Water to make.....	100 gallons

*On Morellos to prevent arsenical injury to the stems, the lead arsenate is reduced to 1 pound in 100 gallons.

If dust is used, a 90-10 sulfur-lead-arsenate mixture is indicated.

Second fruit-fly spray (About ten days later than the first fruit-fly spray or when Montmorency begins to color)

The formula is the same as that for the first fruit-fly spray.

Where the cherries are to be consumed as fresh fruit

It is impossible to recommend a spray schedule which will always give satisfactory maggot control and at the same time will insure freedom from spray residue. The following suggestions are offered:

When arsenicals are used in the fruit-fly sprays

First fruit-fly spray (A week after the fruit flies have first appeared or about the time Early Richmond first shows a tinge of color)

Lime-sulfur	2 gallons
or	
Wettable sulfur (at manufacturers' directions)	
Calcium arsenate	1 pound
Hydrated lime	1 pound
Spreader	½ pound
Water to make.....	100 gallons

If dust is used, a 90-10 sulfur-lead-arsenate mixture is indicated. The same precautions should be taken with dusts as with sprays as regards spray residues. An 80-10-10 sulfur-calcium-arsenate dust may also be used.

Second fruit-fly spray (About ten days after the first fruit-fly spray or when Montmorency begins to color)

Lime-sulfur	2 gallons
or	
Wettable sulfur (at manufacturers' directions)	
Calcium arsenate	½ pound
Hydrated lime	½ pound
Spreader	½ pound
Water to make.....	100 gallons

If dust is used, a 90-10 sulfur-lead-arsenate mixture is indicated. The same precautions should be taken with dusts as with sprays as regards spray residues. An 80-10-10 sulfur-calcium-arsenate dust may also be used.

Where rotenone sprays are used

First fruit-fly spray (A week after the fruit flies have first appeared or about the time Early Richmond first shows a tinge of color)

Finely ground derris or cubé powder
(containing from 4 to 5 per cent of rotenone) 2 pounds
Wettable sulfur (at manufacturers' directions)
Water to make..... 100 gallons

Lime-sulfur should not be used with derris or cubé powder.

Second fruit-fly spray (About one week after the first fruit-fly spray)

The formula is the same as for the first fruit fly spray.

Third fruit-fly spray (About one week after the second fruit-fly spray)

The formula is the same as for the second fruit fly spray.

Some growers may prefer to make only two fruit-fly applications, in which case it is advisable to use 3 pounds of derris or cubé powder to 100 gallons instead of 2 pounds. Two applications may not give so satisfactory control as three applications, particularly if rain periods occur.

After picking spray (Soon after harvest)

Lime-sulfur 2 gallons
Water to make..... 100 gallons

If a dust schedule is followed, an application of dusting sulfur is indicated.

This spray need be applied only in years when leaf spot is present.

BROWN ROT

(Caused by the fungus *Sclerotinia americana* (Wormald) Norton & Ezekiel)

(See also *Peach*, page 75)

The brown rot of stone fruits is particularly destructive to cherries in warm, wet seasons. Sweet cherries are more susceptible than are sour varieties. The life history of the fungus given on page 75 applies also when cherries are infected.

Brown-rot blossom-blight is frequently serious on sweet cherries, and on English Morello among the sour varieties in western New York but appears to be less common in the Hudson Valley. The subsequent development of the fungus on cherry is similar to that described under *Peach* (page 75).

Control

Adequate control of brown rot is obtained in sour cherries by including the 2 gallons of lime-sulfur in the regularly applied sprays for control of leaf-spot, curculio, and fruit-flies. For English Morello, it may be

advisable to start the schedule of sprays with the pre-blossom, while for the other sour cherries the petal-fall will normally be the first spray.

For sweet cherries, lime-sulfur applied in the regular schedule, beginning with the pre-blossom spray, will give adequate control. Where the regular schedule is not followed, applications of fungicides before rainy periods will be required where brown rot is a problem. Growers of sweet cherries usually find that an application of dusting sulfur about a week prior to picking will enable them to leave the crop on the trees longer, thus allowing the fruit to attain greater size without appreciable loss from brown rot. Some difficulty is encountered in obtaining pickers where this practice is followed, because of irritation to their eyes caused by the dust.

BLACK CHERRY APHIS

(*Myzus cerasi* Fabricius)

The black cherry aphid frequently causes serious injury to sweet cherries in New York but is seldom serious on sour cherries. This pest passes the winter in the form of shining black eggs on the smaller branches near the buds. These eggs hatch as the buds are opening in the spring. The aphids reproduce so rapidly that within a few weeks they may curl the leaves of the terminal shoots and the frust clusters. The injured leaves turn brown and die, and the fruit is dwarfed. The aphids also excrete large amounts of honeydew, which collect on the leaves and the fruit. A sooty fungus grows in the honeydew, making the fruit practically unmarketable.

Control

Effective control of the black cherry aphid has been obtained by spraying with tar-distillate emulsion containing 1.8 per cent of tar oil in the diluted mixture. (See table 2, page 96.) The spray should be applied in the spring while the buds are still brown and do not show any green. If this treatment has been omitted, the only alternative is to spray with nicotine sulfate at the green-tip stage.

CHERRY FRUIT-FLIES /

Cherry fruit-flies are present in all the orchards of the State and cause most of the familiar wormy cherries. They are bright-colored flies, somewhat smaller than the house fly and distinguished by prominent dusky bands or markings on the wings. There are two species of these flies: the dark-bodied fruit-fly, *Rhagoletis fausta* Osten Sacken; and the white-banded fruit-fly, *Rhagoletis cingulata* Loew. The abdomen of the dark-bodied fruit-fly is entirely black, while that of the white-banded fruit-fly is marked by a series of distinct white crossbands (figures 14 and 15).



FIGURE 14. THE DARK-BODIED CHERRY FRUIT-FLY (*RHAGOLETIS FAUSTA*)



FIGURE 15. THE WHITE-BANDED CHERRY FRUIT-FLY (*RHAGOLETIS CINGULATA*)

The wing markings of the two species also differ. Both species are present in most orchards, but the white-banded fly is usually by far the more abundant.

The cherry fruit-flies spend about ten months of the year in the soil beneath the trees, in a puparium resembling a grain of wheat. They then change to the fly stage, emerge from the ground, and appear on the trees. In the Hudson Valley, emergence begins about June 1 and continues for a month or longer. The dark-bodied flies begin to appear a week or ten days earlier than do the white-banded flies.

On the trees the flies move actively about over the foliage and the fruit, and suck up drops of moisture, gums, juices, or almost any material present. Particles of solid material are dissolved by means of saliva secreted through the mouth parts.

The female deposits her small, whitish eggs singly in the flesh of the fruit, through small punctures which she makes in the skin with her sharp ovipositor. The eggs hatch into tiny, whitish, legless maggots, which burrow at first around the pit but later through the flesh. The outside of infested fruit usually appears perfectly normal until the maggot is nearly full-grown, when sunken spots appear. When full-grown the maggot eats its way out of the fruit, falls to the ground, and enters the resting stage in the soil.

Control

For many years, lead arsenate at the rate of $2\frac{1}{2}$ pounds in 100 gallons of the spray mixture has given excellent control under commercial conditions. Canning cherries are thoroughly washed before processing, and spray residues are effectively removed, thus permitting the use of a full schedule for fruit-fly control. This schedule cannot be followed on fruit that is to be consumed fresh. Detailed suggestions on possible ways of modifying the spray schedule to prevent excessive spray residues on fruit that is to be consumed fresh are given on page 66. The modified

schedule is built around the substitution of calcium arsenate, which does not adhere so tightly as lead arsenate, or the use of finely ground derris or cubé powder, a material which kills the fruit flies but is not considered objectionable as a spray residue. There is no definite assurance that any of the schedules suggested will always eliminate the residue, so every precaution should be taken to comply with the regulations of the Federal Food and Drug Administration with respect to spray residues.

The best method of timing the sprays is by the use of trap cages to determine just when the flies emerge, supplemented by frequent examination of the trees, beginning about June 1, to determine whether flies are present. This information is available to growers in counties where the farm bureau conducts a spray information service. The first spray should be applied about one week after the beginning of emergence, and should be followed by a second spray ten days to two weeks later. Since Morello cherries are picked later than are the other varieties, a third spray will be necessary on these to protect them until picking time. Morello cherries are susceptible to arsenical injury resulting in shriveling of fruit stems and fruit.

Where information on the emergence of the flies is not available, a fairly satisfactory method of timing is to apply the first spray to all varieties when the Early Richmond cherries are just beginning to show color. Although usually the flies are present earlier, they do not deposit eggs in the fruit until it begins to color a little.

When spraying cherries for the control of fruit-flies, it is essential to spray also interplanted trees and adjoining trees or hedgerows, since otherwise the flies will harbor safely in these, and later will move to the cherries and lay eggs before being poisoned. The first four or five rows of adjoining orchards also should be sprayed. If interplanted with peaches, which cannot be safely sprayed, the cherries should be sprayed as soon as the first flies appear, in order to kill the flies before they can move to the peaches.

Where an effort is being made to prevent spray residue, it is suggested that all trees, bearing and non-bearing, interplanted with cherries, and all trees and hedgerows bordering the orchard, be thoroughly sprayed with lead arsenate. Control of maggot through the use of calcium arsenate, or derris or cubé powder, on the cherry trees themselves would then be made much easier and the danger of excessive spray residues greatly reduced.

Where dusts are used instead of sprays, the covering should be renewed after every heavy rain during the danger period.

CHERRY LEAF-SPOT

(Caused by the fungi *Coccomyces hiemalis* Higgins and *C. lutescens* Higgins)

Cherry leaf-spot is the disease which, when uncontrolled, causes the greatest loss to the cherry industry in New York. In years very favorable to the development of the leaf-spot, such as 1922, 1924, and 1928, many orchards that were not properly sprayed were defoliated. Such defoliation weakens the trees and winterkilling is very likely to follow. In addition to the immediate effect on the following year's crop, defoliation reduces the spur development, thus lowering the production for a number of years.

On an affected leaf, dark blue spots, usually not more than $\frac{1}{8}$ inch in diameter, appear on the upper surface. These spots soon become dark red or reddish brown and extend through the leaf, and during rainy weather light pink-colored masses appear on the underside of the leaf in the center of the spots. The spots may occur on the fruit stems also (figure 16), causing the fruit to ripen unevenly. Spots on the fruit occur rarely and are not of economic importance.

Leaf-spot, a fungous disease, may be confused with a leaf-drop of cherry in which no disease organism is concerned. This physiological leaf-drop is apparently correlated with winter injury to the cherry trees. The leaves of trees affected with physiological leaf drop turn yellow or a lighter shade of green, and drop in large numbers. In most cases this drop begins earlier than does the leaf-drop caused by the leaf-spot fungus. Both troubles may, and frequently do, affect the same tree. The fungous leaf-spot may be positively identified after wet weather by the masses of spores which appear in the center of the spots, usually on the under surface of the leaf. It is important that the grower should be able to identify the true fungous leaf-spot, since it is controlled by spraying while the physiological dropping of leaves is not.

The fungus that causes the leaf-spot has a life history much like that of the apple-scab fungus. The leaf-spot fungus overwinters on the fallen leaves, and its fruiting bodies usually mature during the blossoming period of the cherry. During rain periods the spores are shot out from the fallen leaves and carried up by air currents. If these spores lodge on a leaf, and moisture and temperature conditions are favorable, the spore germinates and a leaf-spot results in one or two weeks. Masses of summer spores are produced during wet weather, usually on the under surface of the leaf. In later rain periods these are carried by rain and wind to healthy leaves, causing new spots which appear one or two weeks later. The disease causes the cherry leaves to turn yellow and fall. Occasionally a leaf forms an abscission layer around a spot, causing it to drop out and produce



FIGURE 16. CHERRY LEAF-SPOT ON LEAVES AND ON FRUIT STEMS

a shot-hole effect. During long, warm rains the spread of the disease is very rapid.

Control

Adequate control of leaf spot is obtained in most years by the use of 2 gallons of lime sulfur in the petal-fall and shuck sprays and the inclusion of lime sulfur or a wettable sulfur in the cherry-maggot sprays. In years in which leaf spot is severe, an after-picking spray of lime sulfur or wettable sulfur is required to prevent early defoliation. Commercial control of leaf spot has also been obtained with sulfur dust.

PLUM CURCULIO

(*Conotrachelus nenuphar* Herbst)

(See also under *Plum and Prune*, page 81)

The plum curculio is present in most cherry orchards and is especially troublesome near stone walls or other hibernating shelter. The larva of the plum curculio is rather thick-set, is curved, and has a distinct head.

The beetles usually begin to attack the fruit shortly after the petals have fallen, and lay most of their eggs during the following two weeks. Unlike most of the other fruits attacked by the curculio, infested cherries usually remain on the tree until picking time.

Control

Sprays containing 2½ pounds of lead arsenate are effective against the plum curculio. The spray should be applied when the shucks are falling from the growing fruits. Lime-sulfur is included in both applications, for control of leaf-spot and brown rot.

PEACH

Under New York conditions, the peach suffers severely from the attacks of three diseases—leaf curl, brown rot, and scab—and, in certain localities, from the ravages of the plum curculio. The oriental fruit-moth is now well established in the State, and no method of control by spraying has been devised.

SPRAY OUTLINE FOR PEACHES

Leaf-curl spray (In late fall or early spring, before the buds swell)

Lime sulfur	6½ gallons
Water to make.....	100 gallons

If San José scale is present, 11 gallons of lime-sulfur should be used. Instead of lime-sulfur a 10-10-100 bordeaux mixture may be used if scale is not important.

Shuck spray (When the shucks are falling from the fruits that are going to set)

Wettable sulfur (at manufacturers' directions)

*Hydrated lime 16 pounds

Lead arsenate 2 pounds

Water to make..... 100 gallons

*Zinc-lime may be substituted for the hydrated lime where arsenical injury has been serious (see page 90 for formula and directions).

This application is made to control brown rot, scab, and curculio.

If dust is used, a 90-10 sulfur-lead-arsenate mixture is indicated.

Summer sprays (The first, two or three weeks after the shucks have fallen; the second, two or four weeks before the fruit ripens)

Wettable sulfur (at manufacturers' directions)

Water to make..... 100 gallons

These sprays are applied for the control of brown rot and scab.

If a dust schedule is followed, an application of dusting sulfur is indicated.

PEACH LEAF-CURL

(Caused by the fungus *Exoascus deformans* (Berkley) Fuckel)

The leaf-curl of peach has long been known by commercial growers as a very injurious disease. In New York, the disease is most common and destructive in the western New York fruit belt along Lake Ontario. Even there it is not present to a serious extent every year, but in wet seasons it causes immense damage to unsprayed orchards.

The loss caused to peach-growers by leaf-curl results from the dropping of leaves in the spring. This loss of leaves lowers the vitality of the trees, may cause a partial or a total failure of the trees to set a crop of fruit, and causes the trees to be much more susceptible to winterkilling. Loss of leaves for several consecutive seasons will kill trees outright. Young nursery stock may be killed or made worthless as a result of leaf-curl.

The disease is first recognized by a reddening and an arching of the young leaves as they begin to appear. Later these leaves become thickened and curled or crinkled, and have a yellowish color and a silvery sheen. These diseased leaves die and drop off in June, and the tree replaces them with a new growth of healthy leaves. Young shoots of the current season's growth may become infected. Swellings develop on these affected twigs and they turn light green or yellow. The flowers and the young fruits also are often attacked, but these soon drop off and are unnoticed by the grower.

The complete life history of the peach-leaf-curl fungus is now known. Spore-bearing sacks (asci) are formed by the fungus in the spring just

under the surface of the curled leaves. Before the diseased leaves dry up and drop to the ground, these sacks ripen their ascospores and discharge them immediately. These ascospores remain lodged on the twigs and upon the scales of the dormant buds through the summer and following winter. There is considerable evidence to show that the ascospores sprout and form spores of another kind, known as *sprout conidia*, whenever the trees are wet with rain for any extended period. These sprout conidia will remain alive for more than a year.

When the buds swell in the spring, the ascospores, or sprout conidia, are washed to the opening leaf buds by the spring rains. There the spores germinate and enter the tender leaf tissue which is exposed, if conditions of moisture and temperature are favorable. As the infected leaves develop they soon show the typical symptoms of leaf curl and the asci of the curl fungus develop and discharge a new crop of ascospores within a few weeks from the time of the infection.

Control

The control of peach leaf-curl is much simpler than the control of other common fungous diseases of fruit. For example, in the control of apple scab there is no practical method of destroying the overwintering form of the fungus. The curl fungus, however, overwinters in the form of spores on the bud scales and the twigs. One thorough application of $6\frac{1}{2}$ gallons of lime-sulfur in 100 gallons of the spray mixture, or of 10-10-100 bordeaux mixture, applied at any time during the dormant period, will control peach leaf-curl. There is a growing tendency among commercial peach growers to apply this spray in the fall. Delaying the spray until spring is dangerous, since the ground in the orchard is often too soft to permit spraying until after the buds have started to swell. When a rain period occurs after the buds have started in the spring, severe leaf-curl is likely to result if the spores have not been destroyed by a spray. Many failures to control leaf-curl result also when the work is not done thoroughly. Every bud should be hit with the spray, and the terminals should be followed out to the tips, to insure perfect control. The spray should not be applied during freezing weather because of the danger of injury.

BROWN ROT

(Caused by the fungus *Sclerotinia americana* (Wormald) Norton & Ezekiel)

Brown rot, an important and destructive disease, is better known as the *brown rot of stone fruits*, since cherries, plums, nectarines, and apricots are attacked by the same fungus. From the appearance of this disease at different times in the season, it is known as *blossom-blight*, *twig-blight*, *fruit-rot*, and

brown-rot canker. While the losses to peach-growers from brown rot are more frequent and severe in the South, the disease is very destructive in New York in warm, wet seasons. Certain varieties, such as Carman and Rochester, are especially susceptible in this State.

All peach-growers are familiar with the appearance of the disease on the ripening fruit, but many overlook the equally important stages on flowers, twigs, and branches.

The brown-rot fungus overwinters in cankers on the branches of trees and in the mummied fruit. About the time the peach buds begin to show pink, the fungus in the fallen mummies produces small, mushroom-like cups from which the ascospores are shot during rains. Other spores (conidia) also are liberated in great numbers from the mummies clinging to the trees and from the cankers on the limbs. These conidia are the more abundant and common form in the spring, and are more important than the ascospores in spreading the disease.

When either type of spore lodges on an opening bud or a blossom, it germinates and grows into the tissue, causing the blossom to turn brown and wither and usually to become covered later with a new crop of the powdery spores. In many cases the fungus grows from the blossom through the fruit spur and into the branch bearing the spur. Here it develops a dead, sunken area, or canker, which exudes large masses of gum. Conidia develop in great numbers in these cankers. Twigs that are attacked blight back to the branch, where a canker develops. Rains and warm, humid weather at the time when the peaches are ripening will cause a large number of the conidia to develop and be liberated from the cankers, and, if unprotected, a large proportion of the fruit may be attacked and may rot. In the order of its appearance, brown rot causes a loss to the commercial peach-grower in three ways: (1) it reduces the set of fruit through blossom blight; (2) it weakens the branches and reduces the bearing life of the trees through cankers on the limbs following twig and blossom blight; and (3) it causes direct loss to the fruit crop.

The reduction of the set of fruit through blossom blight is not of commercial importance in most years, although in certain seasons favorable to blossom-blight infection this has resulted in serious loss in western New York. Blossom blight appears to have been much less prevalent in peaches in the Hudson Valley.

The damage to the fruit is generally recognized, and control measures are applied by most commercial peach-growers.

Control

Sulfur has been found to be highly effective in the control of the brown-rot fungus. Formerly, self-boiled lime-sulfur was largely used, and this

mixture is a very effective and safe material. Owing to the time and the care required in preparing this spray, and the difficulty experienced in obtaining good stone lime, most growers have replaced self-boiled lime-sulfur with dry-mix sulfur-lime or other wettable sulfur sprays or with sulfur dust. These materials have given excellent control of brown rot.

The first application is made when the shucks are falling. A second application is applied, before rains, two or three weeks after the shucks have fallen, and the last spray or dust two to four weeks before the fruit ripens, depending on weather conditions.

A few growers apply lime-sulfur, diluted 1-50, for the summer sprays, but this material is extremely dangerous on peaches after the blossoming period. Lime-sulfur at any dilution may seriously burn peach foliage. Before blossom time, lime-sulfur may be used with safety.

PLUM CURCULIO

(*Conotrachelus nenuphar* Herbst)

(See also under *Plum and Prune*, page 81)

The plum curculio is often a serious pest of the peach in orchards near stone walls, woods, or other hibernating shelters. The beetles make both feeding and egg-laying punctures in the fruit, and cause it to become scarred or wormy. The wormy peaches usually fall, and thus a large proportion of the crop may be lost unless control measures are employed.

Control

The plum curculio can be controlled by spraying with 2 pounds of lead arsenate in combination with the following formula, when the shucks are falling. Whenever lead arsenate is used on peaches, the addition of lime or zinc-lime is necessary to reduce arsenical injury.

The materials to use are given under the shuck spray (page 74).

PEACH SCAB

(Caused by the fungus *Cladosporium carpophilum* Thümen)

Peach scab, known also as *freckles* and *black spot*, occurs to an injurious extent wherever peaches are grown in New York. The damage done by scab is not realized by many growers, who regard the disease as a necessary evil or mistake it for a peculiarity of the affected variety. There is no decay of the fruit, but its market value is lowered. The size is reduced and the fruit may crack. Diseased fruits often drop prematurely, and those that are picked do not ship well. Attacks are most general on late varieties.

Small, round, olive-black spots appear on infected fruits about six weeks after the petals have fallen. These lesions are usually on the upper

side of the fruit. When they are abundant, cracking of the fruit may follow.

Affected twigs show nearly circular yellowish brown blotches with a dark gray or a bluish border. When these are abundant, the cambium is killed and the twigs die.

Leaves also are attacked. Brown, scattering spots develop midway between the main veins, in which the tissue dries up and finally falls away, leaving circular holes.

The fungus overwinters in the twigs, and infections usually occur four or five weeks after the petals have fallen.

Control

Where the regular spray schedule is followed, peach scab is controlled without difficulty.

ORIENTAL FRUIT-MOTH

(*Grapholitha molesta* Busck)

The oriental fruit-moth is a serious pest of the peach now widely distributed through the peach-growing regions of the State. The species winters over as full-grown larvae in cocoons in protected places. In the spring these change to moths, which lay eggs on the foliage. The moths emerge over a long period, and there are at least four broods a year in New York. The larvae of the first brood attack the tips of growing shoots, entering near the tips and burrowing down the twigs for a short distance. This causes the terminal leaves to wilt, turn brown, and die. The larvae of the later broods not only attack the shoots but also infest the fruits. The first and second broods are fairly distinct, but the later generations overlap, so that the moths of three different broods are present on the trees at the same time toward the end of the season. The larvae generally do not attack the fruit until it is two-thirds mature. In many cases, little if any gum is exuded from the entrance holes in the peach, and so it is very difficult to determine without opening a fruit whether or not it is infested. As a result, much infested fruit reaches the market in spite of careful sorting.

Control

No satisfactory control measures have yet been devised. The usual spray methods effective against other pests have not given satisfactory results. The most promising method of reducing injury seems at present to lie in the direction of the importation, breeding, and liberation of parasites. The workers at the New York State Agricultural Experiment Station at Geneva are following this line of attack with promising results.

Numerous colonies of these parasites have been liberated in the Hudson Valley.

PLUM AND PRUNE

The main troubles for which commercial growers of plums and prunes find spraying necessary are plum curculio, leaf-spot, and brown rot. In some plantings, European red mite and black knot may require special attention. Occasionally, outbreaks of the fruit-lecanium scale necessitate an application of an oil spray.

SPRAY OUTLINE FOR PLUMS AND PRUNES

Dormant (After the sap has started and before the buds break)

Lubricating-oil emulsion, diluted to contain 3 per cent of oil (see page 93), is the most practical control measure for European red mite.

This application is needed only in orchards infested by San José scale or fruit lecanium, or in plantings where European red mite is serious.

Shuck spray (When the shucks are falling from the fruits that are going to set)

Wettable sulfur (at manufacturers' directions)

*Hydrated lime	16 pounds
Lead arsenate	2½ pounds
Water to make.....	100 gallons

or

Bordeaux mixture (see page 88).....	2-4-100
Summer oil emulsion.....	1½ gallons
Lead arsenate	2½ pounds
Water to make.....	100 gallons

*Zinc lime may be substituted for lime where arsenical injury has been serious in the past to the leaves. See page 90.

If dust is used, an 80-20 sulfur-lead-arsenate mixture is indicated.

The first formula is effective in checking curculio leaf spot and brown rot and has little effect on European red mite.

The bordeaux-oil formula is effective against red mite in addition to curculio, leaf spot, and brown rot. However, russetting of the fruit has occurred in some orchards where it has been used. The most practical program for red-mite control is the use of the dormant lubricating oil program.

Summer sprays (The first, two or three weeks after the shuck application; the second, two or three weeks before the fruit ripens. Both applications to be made before rain periods)

Wettable sulfur (at manufacturers' directions)

Water to make.....	100 gallons
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If a dust schedule is followed, applications of dusting sulfur are indicated.

If red mite becomes a problem, 1½ gallons of summer oil emulsion may be used, although oils applied late in the season have a tendency to spot the fruit and, in addition, foliage injury may result if sulfur residues are already present.

Japanese varieties

On Japanese varieties, the same schedules as to time of application should be followed. In the dormant period the same materials are used, but in all later applications wettable sulfur at manufacturers' directions, or sulfur dust, is used.

EUROPEAN FRUIT LECANIUM

(*Lecanium corni* Bouché)

At intervals of several years, the European fruit lecanium, a large, brown, soft-bodied, scale insect, appears in injurious numbers more or less locally in New York plum orchards. It occasionally attacks quinces also.

The mature female scales are about ⅛ inch in length and resemble a small halved pea, colored brown. The eggs are produced in late May and in June, and are to be found filling the cavity under the scale previously occupied by the female. They hatch in about a month, and the young insects crawl out on the leaves where they settle down and remain stationary until September. They then migrate back to the twigs, where they pass the winter in a partly grown condition.

Badly infested trees are weakened and lose their foliage, and the fruit remains undersized or falls prematurely. The young scales produce a clear, sweetish liquid known as *honeydew*, which collects on the leaves and the fruit and serves as a medium for the growth of a fungus that smuts the fruit.

Control

The lecanium scale is easily controlled on plum and quince by spraying the trees while dormant with a lubricating-oil emulsion diluted to contain 3 per cent of oil, or with one of the miscible oils used according to manufacturers' recommendations.

EUROPEAN RED MITE

(*Paratetranychus pilosus* Canestrini & Fanzago)

(See also under *Apple*, page 32)

European red mites sometimes cause considerable injury to plums and prunes. When numerous they cause a bronzing of the leaves, which results in a dwarfing of the fruit and a reduction in shoot growth and fruit-bud formation.

Control

The red mite is best controlled on prunes by a dormant application of a 3-per-cent-lubricating-oil-emulsion spray. Where the grower does not choose to make a dormant oil application, the bordeaux-oil combination at the shuck spray will prove effective and will also hold in check leaf spot, brown rot, and plum curculio. However, this program may cause some russetting of the fruit.

Summer sprays of dilute lime-sulfur as applied for the control of leaf-spot will usually control red mite satisfactorily but are likely to cause too much foliage injury. The use of wettable sulfur or sulfur dust has a tendency to permit an increase of red mites. If the dormant oil application or the shuck spray with bordeaux-oil has been omitted and the mite appears in threatening numbers in the summer, they may be controlled by spraying with summer oil (1½ gallons of the emulsion in 100 gallons of water). Growers should make sure that sulfur residue from previous sprays is not present on the foliage.

PLUM CURCULIO

(*Conotrachelus nemuphar* Herbst)

The plum curculio is the most serious pest attacking plums in eastern New York, and it causes considerable injury to cherries, peaches, and apples also. This insect is most abundant and destructive in orchards adjoining stone walls, hedgerows, and other protected situations, which offer shelter for the overwintering beetles.

The adult plum curculio is a rough-looking grayish beetle with a hump on the middle of each wing cover. The chewing mouth-parts are on the end of a long snout which projects from the head somewhat like an elephant's trunk. The beetles pass the winter in sheltered situations near the orchard, and appear on the trees in May, usually at about the blossoming period of domestic plums. Previous to the setting of the fruit, the beetles feed on the leaves and the petals. Soon after the petals have fallen, the beetles attack the fruit, which they injure both by feeding and by egg-laying. The eggs are deposited in the fruit in characteristic crescent-shaped cuts, which, on apples, enlarge as the fruit grows and form D-shaped russeted scars. The feeding punctures are small, circular excavations which are undercut around the edges. Feeding punctures may occur at any time during the season when the beetles are active. Egg-laying is limited mainly to a period of three weeks, beginning on stone fruits about the time the shucks are falling and on apples soon after petal-fall. The eggs hatch in about a week, and the larvae live in the flesh of the fruit and become full-grown about two weeks after hatching.

The larvae are dirty yellow in color, thickset, and rather strongly curved, with a distinct head. Except in the case of the cherry, most of the fruits containing larvae fall to the ground. When mature, the larvae leave the fallen fruit and enter the soil to a depth of one or two inches, where they construct earthen cells. Most of the larvae leave the fruit during the first two weeks in July. After about two weeks in the soil, the larvae change through the pupal stage to beetles. The beetles of the new brood emerge from the ground during August. They may feed on the fruit to a considerable extent during late summer and fall, but they do not lay eggs until the following spring. In New York there is only one generation of the plum curculio in a season.

Control

The plum curculio is controlled by sprays containing 2½ pounds of lead arsenate in 100 gallons of the spray mixture. The first spray is applied as soon as the shucks have fallen from the growing fruits. In badly infested orchards a second spray may be required a week later.

PLUM LEAF-SPOT

(Caused by the fungus *Coccomyces prunophorae* Higgins)

Plum leaf-spot is caused by a fungus which is very similar to the cherry-leaf-spot fungus in its life history (page 71) but matures slightly later in the spring. The leaf-spots on plum are similar in appearance to those on cherry, but the shot-hole effect is much commoner. The effect of heavy leaf infection is much more serious on the current season's plum crop than on the cherry crop, because a heavy fruit-drop often follows the leaf infection. The spray schedule followed for the control of plum leaf-spot consists of a spray when the shucks are off the young fruit, a second spray two or three weeks later, and a third spray before the fruit ripens. The last two sprays should be timed to precede rain periods. Lime-sulfur (2 gallons in 100 gallons of the spray mixture), wettable sulfur, and sulfur dust, have all given adequate control when properly applied.

BROWN ROT

(Caused by the fungus *Sclerotinia americana* (Wormald) Norton & Ezekiel)

(See also *Peach*, page 75)

The brown rot of stone fruits is a serious disease on plums and prunes in New York. The life history of the fungus causing this disease is given on page 75.

Control

Where the regular spray schedule is followed, adequate control of brown rot is obtained.

BLACK KNOT

(Caused by the fungus *Plowrightia morbosa* (Schweinitz) Saccardo)

Black knot is a serious disease of plum and prune. It occurs on wild and cultivated forms of both plum and cherry, but is much commoner on plum.

The disease affects only the woody parts. It is confined usually to the twigs, but is found occasionally on the larger limbs and the trunk. The knots vary from $\frac{1}{2}$ inch to 1 foot or more in length, and from a fraction of an inch to 2 inches in circumference. The knots usually do not completely surround the limb. In the spring the young knots are olive green in color, and are firm but rather pulpy. Later the knots turn black and become hard and brittle.

The olive-green knots are the points from which the spores of the fungus are spread. During April, May, and June, some of these spores lodge on other trees, germinate, and grow into the bark and the growing tissue. The irritation causes the tree to develop a large amount of bark tissue, which appears in the fall as a slight swelling. In the spring the new knot enlarges and splits open, and the fungus soon forms its spores, giving the knot a velvety-green appearance.

Control

This trouble may be remedied by pruning out the knots during the winter or before growth starts in the spring. The cut should be made about 4 inches below the base of the visible swelling. A second inspection should be given the orchard during the latter part of May, to remove knots which were not visible in the winter but which would swell rapidly in the spring and produce spores that would spread the disease. It is important that all pruned knots be burned immediately. When knots develop on large limbs or trunks, the knotted tissue should be carefully removed for about $\frac{1}{2}$ inch beyond the boundary of the knots. It is not necessary to remove much wood, even beneath the visibly knotted area. All plums, prunes, and cherries in the near vicinity, both cultivated and wild, should be pruned or removed.

Where black knot is a serious problem, a delayed-dormant spray should be applied about the time the buds are breaking, in addition to the regular shuck and summer sprays on plums and prunes. For the delayed-dormant spray, liquid lime-sulfur diluted 1-8 with water or a 6-12-100 bordeaux-oil-

emulsion spray containing 3 per cent of oil have given good results during the past five years. The oil in the mixture will be effective against red mites also.

SPRAY MATERIALS

The number of spray materials that can be used advantageously in the average commercial orchard under New York conditions is limited to a relatively short list of standard fungicides and insecticides. The most important of these are lime-sulfur, wettable sulfurs, lead arsenate, and nicotine sulfate, for general use, and bordeaux mixture, dry-mix sulfur-lime, and oil preparations, for special purposes. Of the many proprietary spray compounds on the market, few, if any, are superior to the standard materials. They are usually much more expensive, are less effective, and under certain conditions are much more toxic to the trees. The large sums of money expended each year on materials of this kind, together with the losses due to ineffective control from their use, constitute a serious drain on the resources of the fruit interests of the State.

It is the custom to divide spray materials into insecticides and fungicides, but in the light of present-day knowledge this distinction is not so clear-cut as was formerly thought to be the case. Lime-sulfur is both an effective insecticide and an efficient fungicide. Lead arsenate is used primarily for control of chewing insects, but when combined with lime-sulfur it has considerable value as a fungicide also. Bordeaux mixture is essentially a fungicide, but it may serve as an effective insecticide as in the case of potato leaf-hopper. Nicotine alone, among the standard spray materials, is used exclusively for its insecticidal properties.

The selection of the standard materials now generally used is not a matter of chance, but is based on results obtained by practical growers during many years of experience. That this choice is sound, in the main, has been proved time and again by the experimental tests conducted by the workers at experiment stations.

It is a very expensive matter to conduct tests of the relative value of different kinds of spray materials if dependable results are to be obtained. The average fruit-grower has neither the time nor the funds for experimental work of this kind. Unless the experiments are properly planned and carefully conducted, the results are likely to be misleading. In general, it is better for the individual grower to rely on the results obtained by experiment stations, which are supplied with public funds for this purpose.

SULFUR SPRAYS

Lime-sulfur solution

Lime-sulfur has a wide range of usefulness in orchard spraying. At the higher concentrations it is effective against peach leaf-curl, San José

scale, and the eggs of the pear psylla. At the summer strength of 1-50, it is the chief reliance in New York in the control of such important diseases as apple scab and cherry leaf-spot, and, when used in pre-blossom and petal-fall sprays reduces or prevents injury from the European red mite.

Lime-sulfur solution is prepared by boiling freshly burned high-grade calcium lime with sulfur and water. The commercial concentrate generally sold is a clear, orange-red solution usually containing between 25 and 26 per cent of total dissolved sulfur and testing from 32° to 33° Baumé. While most commercial brands test approximately as indicated, there may be considerable variation, and the safest plan is to test each barrel with a hydrometer, preferably one marked with a Baumé scale. All recommendations in this bulletin as to the quantity of lime-sulfur to be used are based on a solution testing 32° Baumé. If solutions of other strengths are used, corrections should be made according to table 1.

TABLE 1. LIME-SULFUR DILUTION TABLE

Hydrometer reading in degrees Baumé	Gallons of lime-sulfur used in 100 gallons of spray			
32° (standard test)	11	6½	2½	2
20°	22½	13	5	4
21°	20½	12½	4½	3½
22°	19½	11½	4½	3½
23°	18½	10½	4	3½
24°	17	10	3½	3
25°	16	9½	3½	3
26°	15	8½	3½	2½
27°	14½	8½	3½	2½
28°	13½	8	3	2½
29°	12½	7½	2½	2½
30°	12½	7½	2½	2½
31°	11½	6½	2½	2
32°	11	6½	2½	2
33°	10½	6	2½	2
34°	10½	6	2½	1½
35°	9½	5½	2½	1½

In recent years it has been the practice to ship commercial lime-sulfur in steel drums. In many cases these drums have previously been used for oil. Unless the drums are carefully cleaned, there is danger of injuring the trees from the mixture of oil and lime-sulfur.

It is possible to make concentrated lime-sulfur solution on the farm if one wishes to go to the trouble and the expense for equipment. Directions for preparing the homemade solution can be obtained from the state experiment stations.

Other sulfur sprays

Much confusion exists regarding the sulfur sprays in common use, owing to the similarity of names and the variety of names often applied

to the same material. *Lime-sulfur solution* refers to the liquid obtained by boiling lime, sulfur, and water. *Dry lime-sulfur* is a yellow, pungent powder obtained by evaporating lime-sulfur solution. *Dry-mix sulfur-lime*, also known as *Jersey dry-mix* and as *wettable sulfur*, is a dry mechanical mixture of sulfur, lime, and a spreader, to be used in water as a spray. The name *wettable sulfur* is applied also to a number of sulfur materials containing a substance for wetting the particles when mixed with water. The relative merits of these materials for scab control have not yet been definitely determined. Most of the wettable sulfurs are effective when perfectly timed, but they do not possess the after-rain effect of liquid lime-sulfur. Dry lime-sulfur is intermediate between liquid lime-sulfur and the elemental-sulfur applications, in after-rain control. The elemental-sulfur applications are also much less effective in burning out scab lesions that are already present on the foliage.

One of the wettable sulfurs which has attracted considerable attention during recent years is *flotation sulfur*. This by-product of illuminating-gas manufacture is now on the market in both paste and powder form. The experimental evidence in this State indicates that this material is less toxic to apple foliage than is lime-sulfur, and is apparently one of the more effective wettable sulfurs as a fungicide.

Sodium sulfide is a compound of sulfur and sodium. It is sold under a number of trade names, both in the form of a powder and as a solution. It has been discarded by most commercial fruit-growers because of the frequency with which injury to the trees results from its use.

Dry lime-sulfur

Dry lime-sulfur is liquid lime-sulfur with the water (comprising about 70 per cent of its weight) removed. The removal of the water changes somewhat the state of the sulfur. The percentage of sulfur in the polysulfide, or soluble, form is reduced during the evaporating process. Tests made at various experiment stations indicate that about 4 pounds of the powder is required to equal 1 gallon of lime-sulfur concentrate when used for spraying at summer strength. It may readily be seen that at current prices per pound the evaporated product is much more expensive than the liquid. Dry lime-sulfur is being recommended and used by some Middle Western States as a means of reducing the danger of spray injury. In New York, when a milder spray substitute for the liquid lime-sulfur is required during weather conducive to injury, the tendency has been to use one of the wettable sulfurs for this purpose, rather than dry lime-sulfur. Wettable sulfurs depositing a large amount of visible residue should be avoided in late summer sprays.

Homemade wettable sulfur (dry-mix sulfur-lime)

Homemade wettable sulfur is now usually prepared according to the following formula:

Superfine sulfur (325 mesh).....	8 pounds
Hydrated lime (omit if already in formula)....	3 pounds
Spreader	$\frac{1}{2}$ pound
Water to make.....	100 gallons

The materials are mixed dry in the proportions given in the formula, a screen or a dust mixer being used, and are stored in a dry place until the time for their use. With the tank half full of water and the agitator running, the required quantity of the dry material is washed through the strainer into the tank by means of the open spray gun.

Some growers weigh out the correct amount of spreader, hydrated lime, and sulfur for each tank. The spreader is first washed through the screen into the tank, and the hydrated lime and the sulfur are then washed through with the open spray gun. If the tank is more than half full of water and the agitator is running, this method is found to be as satisfactory as the previous dry-mixing of the materials.

Dry-mix sulfur-lime or homemade wettable sulfur has supplanted self-boiled lime-sulfur for use on peaches, because it is much more convenient, is equally effective, and, considering the labor cost, is cheaper than the self-boiled material. It has been discovered, however, that when lead arsenate is applied with dry-mix, it is more likely to cause arsenical injury to such tender trees as the peach than when it is combined with self-boiled lime-sulfur. To decrease this danger, not more than 2 pounds of lead arsenate should be used and excess hydrated lime should be added to make 16 pounds of lime for each 100 gallons of the spray mixture on peaches. Zinc lime (see page 90) is more effective than lime alone in preventing arsenical injury.

Wettable sulfurs are used as a substitute for lime-sulfur for summer sprays on apples and for the bordeaux-mixture spray on pears. They are less effective than summer-strength lime-sulfur in checking the spread of apple scab already present in the orchard.

Experienced growers who are using a wettable sulfur for summer sprays on apples do so only when they are convinced that they already have the scab under commercial control in their orchards. They wish to reduce the danger of spray injury to foliage and fruit, and to insure as high a finish as possible on the fruit.

It should be remembered, however, that under certain unfavorable weather conditions injury may result with any of these materials. This is most likely to occur when heavy applications are made during or

immediately preceding periods of excessive heat. Under such conditions, applications even of sulfur dust may cause serious burning.

SULFUR DUST

Sulfur dust is generally used in combination with lead arsenate, but for certain purposes it is used alone. To be most effective, it should be so finely ground that 90 per cent will pass through a screen having 325 meshes to the inch. When sulfur dust is not combined with lead arsenate, a small percentage of "fluffer" is added to prevent packing of the dust and to insure a fine cloud of dust when it is applied.

New sulfur dusts have come into use which contain colloidal sulfur, and others which contain dry lime-sulfur. These materials, and also sulfur dust containing various oxidizing and activating agents, are now being extensively tested.

BORDEAUX MIXTURE

Bordeaux mixture may be used on apples as an emulsifier for oil sprays prior to the delayed-dormant spray. It is also used to a limited extent in the summer in combination with summer oil and on the spray immediately preceding applications of summer oils to prevent injury resulting from these oils with sulfur sprays or on trees carrying a sulfur residue. A 2-4-100 bordeaux mixture appears to be adequate for scab control in these summer sprays, and superior to the proprietary copper sprays in scab control.

The use on apples of any copper compound now known is attended with some danger of injury to foliage and fruit. The most dangerous period is from the delayed-dormant spray through the first cover spray. Any of the later sprays also may be injurious. Copper injury is most likely to occur during periods of cool wet weather, while in periods of extreme heat much less injury may occur than results from sulfur applications. Wettable sulfurs have only resulted in serious spray injury on apples in one year in the past decade in this State while serious spray injury has resulted from copper sprays in some sections of the State every year during this period. In addition to apples, bordeaux mixture is used as an emulsifier of lubricating oil sprays on pears, quinces, prunes, and plums for the control of various insects.

Promising results for two years have also been obtained with a combination of bordeaux mixture with summer oils for the shuck spray on prunes. A weak bordeaux mixture with a large amount of hydrated lime to reduce the danger of russetting the fruit is used as a fungicide on pears.

Preparation of mixture

Instant method of preparing bordeaux mixture

This method depends upon the use of finely powdered copper sulfate. This material should be as fine in texture as high-grade table salt. The chemical hydrated lime should be of such fineness that 98 per cent will pass through a 300-mesh sieve.

For each 100 gallons of 2-4-100 bordeaux mixture (1) Weigh out 2 pounds powdered copper sulfate and 4 pounds hydrated lime; (2) fill the spray tank one-fourth full of water; (3) start the agitator; (4) add the powdered copper sulfate by washing it through the strainer or sifting in slowly; (5) add water until the tank is three-fourths full, with agitator running; (6) add the hydrated lime as a thin paste; (7) fill the tank and allow the engine to run at least a minute longer.

Vigorous agitation is essential. If agitation is poor, spray the mixture back into the tank.

Old method of preparing bordeaux mixture

Copper sulfate crystals are used in the old method. A stock solution of copper sulfate (blue vitriol) is made by weighing out 1 pound of the crystals for each gallon of water. Usually from 40 to 45 pounds of the copper sulfate crystals are placed in a clean burlap sack and suspended in the top of a barrel containing as many gallons of water as there are pounds of vitriol. Even in cold water, the vitriol will usually dissolve in five or six hours. The barrel should be covered to prevent evaporation and keep the solution clean. No iron should be allowed to come in contact with the solution.

A stock solution of lime is prepared in another barrel by stirring from 20 to 25 pounds of hydrated spray lime into an equal number of gallons of water.

The stock solutions are stirred thoroughly before using them.

To prepare a 2-4-100 bordeaux mixture, the tanks is filled three-fourths full of water, the agitator is started, and 2 gallons of the copper sulfate stock solution is added for each 100 gallons of spray. After the copper sulfate has been well mixed with the water, 4 gallons of the stock lime is added through the strainer for each 100 gallons of spray, with the agitator running. A sky-blue bordeaux mixture should result. The tank is then filled with water.

When bordeaux mixture is used for emulsifying oils, the copper sulfate and hydrated lime are added to a small quantity of water in the spray tank and the oil is thoroughly emulsified with this concentrated bordeaux before filling the tank with water. (See page 94.)

ZINC-LIME

Zinc-lime, a spray mixture, new to New York State, is now used extensively on peaches in the South and Middle West. Originally introduced as a control measure for bacterial spot, its greatest value now appears to be as a corrective for arsenical injury.

Arsenical injury is frequently serious on peaches in the Hudson Valley causing leaf spotting and dropping, and injury to the wood. This injury has been called *bacterial spot*, but examination of a large number of affected orchards has shown that most of the trouble is the result of arsenical injury.

Limited tests in western New York indicate that zinc-lime is superior to hydrated lime in reducing arsenical injury on both peaches and prunes. Zinc-lime is not safe on apples because of the danger of russetting the fruit. Russetting of prunes has not resulted in the past three years from zinc-lime but this possibility should not be overlooked.

The use of zinc-lime is suggested only in sprays containing lead arsenate as a substitute for the excess lime. Since the zinc mixture has little fungicidal value, it should be used in combination with dry mix or other wettable sulfur.

Zinc-lime is prepared according to the following formula:

*Zinc sulfate (crystals)	8 pounds
Hydrated lime	8 pounds
Water to make.....	100 gallons

*Five pounds of zinc sulfate (monohydrate) may be substituted for 8 pounds of the zinc sulfate (crystals).

1. Begin filling the tank with the agitator running.
2. Sift in gradually the zinc sulfate, which will dissolve in one or two minutes.
3. Continue to add water and add the lime, preferably as a thin paste. When the zinc-lime is thoroughly agitated, add the dry-mix or other wettable sulfur. (The lime in the zinc-lime is sufficient, no more lime need be added with the sulfur). Pour the lead arsenate, made into a thin paste, through the strainer, with the agitator running, and apply the spray at once.

LEAD ARSENATE

For many years, lead arsenate has been the standard arsenical used in the commercial orchards of New York. This is because it is much safer, stays suspended in water longer owing to its extreme fineness, and adheres more firmly to the plant, thus protecting the crop over a longer period of time, than any of the earlier types of arsenicals. Lead arsenate can be used with lime-sulfur sprays as well as with most other standard fungicides and insecticides. Unfortunately, lead arsenate, when used in the later applications, is likely to leave objectionable lead residues, as well

as arsenical residues, on the fruit. If used in these sprays, it should be applied with great care or the grower should be prepared to remove excess residue by washing.

When employed in dusting orchard fruits, from 5 to 20 per cent by weight of lead arsenate, depending on the insects to be combated, is used in combination with sulfur dust. A 90-10 sulfur-lead-arsenate dust is most commonly used.

CALCIUM ARSENATE

Calcium arsenate is similar to lead arsenate, the lead being replaced by calcium. It is the most promising substitute for lead arsenate for use in the later applications. It is effective against the cherry fruit-fly and the apple maggot, but is not quite so effective in codling-moth control as is lead arsenate. Under certain conditions it has a greater tendency to cause foliage injury. It is not safe to be used alone on orchard trees, because of the danger of burning; 3 pounds of hydrated lime should be added to the spray mixture for each pound of calcium arsenate used. It should not be used on peaches because of the danger of injury to leaves, twigs, and fruit. Different brands of calcium arsenate vary greatly in quality; some are much safer to use than others. Calcium arsenate is likely to deteriorate if held over for the following year; it is less likely to cause injury if recently manufactured.

In selecting calcium arsenate, the grower should keep in mind that there are great variations in the safeness of the brands offered for sale at the present time. A grower should select a type of calcium arsenate that is stated by the manufacturer as being suitable for use on fruit trees. Additional suggestions on the uses and limitations of calcium arsenate are given in the codling-moth discussion on page 36.

NICOTINE

For spraying purposes, nicotine is sold usually in the form of nicotine sulfate. The standard brands of nicotine sulfate on the market contain 40 per cent of nicotine. Nicotine sulfate is not volatile, but the fumes of the nicotine are liberated when the material is applied as a spray in combination with lime-sulfur, wettable sulfurs, or bordeaux mixture. If used in water alone, from 3 to 5 pounds of potash fish oil soap or 1 pound of soap flakes should be dissolved in each 100 gallons of the spray mixture.

Several nicotine preparations popularly known as *fixed nicotines* are on the market. They have been primarily developed for use against codling moth where it is desired to have the nicotine effective over a considerable period of time. They have not proven effective in the control of apple maggot. A common fixing agent is a special type of bentonite clay. Care

should be taken to use the preparation in a neutral spray mixture; that is, lime, lime-sulfur, and the like, should be omitted.

Nicotine dust is usually made by mixing nicotine sulfate with hydrated lime. Nicotine-lime dusts can be bought ready-mixed, or they can be prepared in a ball-mixer or a self-mixing duster. Since the commercial brands of nicotine sulfate contain 40 per cent by weight of nicotine, 5 pounds, or 2 quarts, of this material is added to 95 pounds of hydrated lime to give a dust containing 2 per cent of nicotine. For a 3-per-cent-nicotine lime dust $7\frac{1}{2}$ pounds, or 3 quarts, is required. Since the nicotine strength is likely to deteriorate if the material is stored for a considerable time, it is well to use only freshly mixed dust.

SOAP

Soaps are used with nicotine sulfate and water to liberate the nicotine and to increase the wetting and spreading qualities.

The soap most commonly used for spraying purposes is potash fish-oil soap. This is a soft soap, dissolving easily in water. Soda fish-oil soap is a harder soap which is sometimes used but is more difficult to dissolve. Resin fish-oil soap has the advantage of not curdling in hard water or when used in spray tanks containing lime residues. Laundry soaps are used occasionally, but these are difficult to dissolve and vary greatly in the amount of free alkali present. Some brands of flaked soap dissolve rather readily, are convenient to handle, and are usually used at the rate of one pound to 100 gallons.

Soaps differ considerably in water content. The amount of soap to be used, therefore, varies from 3 to 5 pounds in 100 gallons of the spray mixture. For safety, a soap with only a little free alkali should be employed. In general, soap should not be used in combination with lime-sulfur.

SPREADERS AND STICKERS

A number of materials may be added to spray mixtures that will give more uniform coverage and better adhesion on the leaves and fruit. In mixing spray in the tank, it is usually advisable to add these spreaders before any other of the spray materials. The materials most commonly used for this purpose are soap; skimmilk powder combined with lime; lignin-pitch, or soybean flour.

Although soap is useful as a spreader and activator in combination with nicotine sulfate, it should not be used with arsenicals or lime-sulfur.

Either skimmilk combined with lime, lignin-pitch, or soybean flour may be used with the common spray materials. Lignin-pitch is being suggested for use with lead arsenate and lime-sulfur combinations and as an emulsified for homemade lubricating-oil emulsions.

Skimmilk powder and lime is suggested for use in summer applications for codling-moth control. Soybean flour and lime (1 pound of each to 100 gallons) has given very promising results in cases of severe codling-moth infestation.

Many of the commercial wettable sulfur preparations contain a considerable amount of spreader, and the use of an additional spreading agent may result in an excessive amount of spreader which causes an undue run-off of the spray and reduces the adherence of the fungicide. A small amount of summer oil is sometimes used as a sticker. Its usefulness is limited because it should not be used with sulfur fungicides and, also, it adds to the difficulty of spray-residue removal.

PETROLEUM-OIL SPRAYS

Oil sprays of the petroleum type have been found of considerable value in the following cases: for use against the lecanium scale and the San José scale; in severe infestations of leaf-roller eggs, for which these sprays are almost indispensable; for the pear psylla, to check egg-laying and to destroy the newly-hatched nymphs; and for killing the eggs of the European red mite when a seasonal program of lime-sulfur sprays on apple cannot be followed. Growers contemplating the use of oil sprays should consider carefully the different brands from the viewpoint of safety and insecticidal efficiency.

The use of oil sprays may be attended with more or less danger of injury to the tree. Injurious cumulative effects may result from yearly applications, although with certain grades of oil and with weak dilutions the possibility of danger from this practice has been overemphasized. Until more is known in regard to the composition of oil sprays that are safe and efficient, the possibility of injury from their continuous use should be kept in mind and the grower should be prepared to discontinue such applications for a time and to rely on other spray material.

Many oil preparations are available for spray purposes. These may be divided roughly into lubricating-oil emulsions and miscible oils.

Commercial lubricating-oil emulsions

Commercial or stock oil emulsions usually contain a certain amount of petroleum oil with an emulsifier added so that the oil will mix with water in the spray tank. They are generally of the mayonnaise type and usually contain 66 or 83 per cent of actual oil.

In recent years, certain grades of lubricating oils have been found to have decided merits in the preparation of oil emulsions for spraying purposes. Oils having the following specifications should prove satisfactory:

Viscosity at 100° F. (Saybolt), 100–120 seconds; specific gravity, 0.88–0.90; Baumé gravity, 24°–28°; flash point, 350°–280° F.; fire point, 400°–435° F.; cold test, 18°–32° F.; volatility after four hours (220°–230° F.), not over 2 per cent, and an unsulfonated residue of 60 to 70 per cent.

Stable concentrated emulsions of these or similar grades of oil can be purchased on the market under various trade names. In most of these preparations the emulsifier is soap, gum, clay, casein, or combinations of these and other materials. The oil content of the preparations should be indicated on the label, and is usually about 66 per cent or 83 per cent as stated above. If a 66-per-cent stock emulsion is used, it should be diluted according to the following directions:

For a 2-per-cent emulsion, use 3 gallons of stock solution	} for 100 gallons
For a 3-per-cent emulsion, use 4½ gallons of stock solution	
For a 4-per-cent emulsion, use 6 gallons of stock solution	
For a 6-per-cent emulsion, use 9 gallons of stock solution	

While these stock emulsions are reasonably stable, if they are allowed to freeze or are stored for considerable periods of time some of the oil may separate out. If the stock emulsion shows any considerable amount of free oil, and preliminary efforts show it will not emulsify properly it is unsafe for use and should be discarded.

Miscible oils

Miscible oils are proprietary oil products which are usually high in oil content and are rendered miscible by the presence of an emulsifier so that an emulsion is produced when they are added to the water in the spray tank. Since miscible oils vary in composition according to the formulas of the different manufacturers, it is advisable to follow the manufacturers' recommendations as to dilution and methods of application.

Tank-mixed lubricating-oil emulsions

Lubricating-oil emulsions can be prepared for immediate use directly in the spray tank. Emulsions prepared in this way are considerably less expensive and the spray material is equally effective. In preparing a tank-mixed emulsion, it is advisable to choose an oil which meets the specifications listed above.

The tank-mixed emulsions are prepared by several formulas. Many growers prefer to emulsify the oil in the tank, using lignin-pitch as the emulsifier. With the agitator running, put about 10 gallons of water in the tank or enough so that pump can work. Wash one-half pound of lignin-pitch through the screen by means of the spray gun. When it is

thoroughly dissolved in the water, add the proper quantity of oil slowly with the agitator running and with the spray gun turned into the tank. When it is emulsified, add the full amount of water and spray out at once. The quantity of lignin-pitch required will depend on the water used. If the mixture foams too much, reduce the quantity.

Another method is as follows: Place sufficient water in the spray tank so that the pump can work. Do not start the engine. For each 100 gallons of spray, add 1 pound of copper sulfate dissolved in water, then add 2 pounds of hydrated lime also in water, stirring meanwhile, with a stick or a paddle. Start the engine, and slowly pour in the proper number of gallons of oil to give the percentage desired in the completed mixture. Direct the spray gun into the tank and continue the agitation until the oil is properly emulsified. In a few minutes or as soon as the oil is thoroughly emulsified, fill the tank with water, keeping the engine running continuously until the tank has been sprayed out. If it is necessary to stop the sprayer, and any considerable quantity of oil separates out, (streaks of free oil floating on the surface) the remainder in the tank should be discarded unless it can be brought back into an emulsion. If more copper is desired for fungicidal purposes, use 3 or 4 pounds of copper sulfate and twice as many pounds of hydrated lime.

Summer-oil emulsions

Emulsions of highly refined mineral oils, often referred to as *white oils* or *summer oils*, have been designed for use on foliage but have limited uses. There is especial danger in their use on foliage containing sulfur residues.

TAR-DISTILLATE EMULSIONS

Various brands of tar-distillate emulsions or tar washes are now widely used at the dormant stage for spraying purposes in this State. The tar oil referred to here is coal-tar oil and not water gas tar oil. These preparations consist chiefly of coal-tar creosote oil, also known as *tar oil*, emulsified with various materials so that they mix readily with water.

The effect of these materials on aphid eggs, bud moth, oyster shell scale and scurfy scale depends on the amount of tar oil present in the diluted spray.

Tar distillate emulsions are not effective against the San José scale. In some brands, petroleum oil has been added in the general proportions of 37 parts tar oil and 46 parts lubricating oil to make them effective against this scale also.

It has been found, however, that, for severe infestations of San José scale, about 3 per cent of petroleum oil is necessary in the diluted mixture, whether or not it is combined with tar-distillate emulsions. It has

been found also that there is danger of injuring the trees by spraying with mixtures containing more than 6 per cent of total oils, either petroleum, tar, or a mixture of both.

If the trees have been injured by low winter temperatures during the past winter, these tar-lubricating oil combinations should be used with great caution.

The type of oil to be selected will depend upon the insect or combination of insects to be combated. Therefore, in choosing a tar distillate emulsion, a grower should satisfy himself as to the percentage of tar oil and petroleum oil present. The tar acid content should be not more than 10 per cent, and perhaps 5 per cent or even less would be better. Occasionally a brand will not mix well with the water available on the farm. The grower should make sure that the brand which he selects will be satisfactory in this respect. Difficulties in getting any particular oil to emulsify may possibly be corrected by adding $\frac{1}{2}$ pound of lignin-pitch to the mixture in the tank.

The recommendations for dilutions in this bulletin are given in the percentage of tar oil in the diluted mixture.

If the percentage of creosote and petroleum oils in the emulsion is known, the proper dilution can be determined from table 2.

TABLE 2. DILUTION TABLE FOR TAR-DISTILLATE EMULSIONS*

Per cent of oil in stock emulsion as purchased		Number of gallons of emulsion to be used for 100 gallons of spray mixture				
Tar oil	Petroleum oil	For cherry aphid (1.8 per cent tar oil)	For rosy aphid (2.4 per cent tar oil)	For light infestation of bud moth or oyster-shell scale (3 per cent tar oil)	For scurfy scale (4 per cent tar oil)	For severe bud-moth, and oyster-shell-scale infestation (4.5 per cent tar oil)
85	0	2.1	2.8	3.5	4.7	5.3
†83	0	2.2	2.9	3.6	4.8	5.4
80	0	2.3	3.0	3.8	5.0	5.6
65	15	2.8	3.7	4.6	6.2	6.9
60	23	3.0	4.0	5.0	6.7	7.5
50	33	3.6	4.8	6.0	...	...
40	40	4.5	6.0	7.5	...	...
†37	46	4.9	6.5	...	...	...
36	44	5.0	6.7	...	...	...

*0.1 gallon equals approximately $\frac{1}{2}$ pint.

†These two oils are the ones most commonly offered for sale in New York State.